



**Karolinska
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Master's Programme in Health Informatics
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Promoting knowledge work practices in Health Informatics Education:
Exploring students' and teachers' views and expectations

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Affirmation

I hereby affirm that this Master thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text. This work has not been submitted for any other degree or professional qualification except as specified; nor has it been published.

Stockholm, 12.08.14

Elnta Meragia



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Abstract

Background: Education is challenged to offer new type of competencies. Especially in health informatics this need is also emphasized. Trialological learning is a strategic educational approach that targets towards the development of work related competencies through the implementation of a set of design principles.

Objective: This study has two major purposes: (1) to investigate students' and teachers' views and expectations on knowledge work practices in health informatics and (2) adapt a course by integrating the Trialological learning design principles into it, in order to investigate the degree to which the principles can be applied in health informatics education

Methods: Ten students and one teacher were recruited as participants. The students' and teacher's expectations were collected through web questionnaires and a semi structured interview respectively. The implementation of the design principles was investigated through pre and post semi-structured interviews to the teacher in the beginning and in the end of the modified course. The students were approached through a standardized open-ended group interview in the middle of the course, observations on their online work and seminars which complemented the group interviews followed, and a Contextual Knowledge Practices questionnaire in the end of the course assessed quantitatively the implementation of the design principles.

Results: The participants expressed the need and importance of developing modern knowledge work practices throughout education. The implementation of the course under Trialological learning was received quite well. In total it was agreed that the design principles were implemented to a good degree and especially the ones to which more emphasis was given throughout the course adaptation.

Conclusion: This study demonstrated a novel way of transforming a course under Trialological learning approach and where the design principles worked as a starting point to modify it. Future design-based research is suggested in order to explore in depth all the design principles.

Keywords: pedagogical design, trialological learning, design principles, knowledge creation metaphor

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List of Abbreviations

KP-Lab	Knowledge Practices Laboratory
KCM	Knowledge Creation Metaphor
AM	Acquisition Metaphor
PM	Participation Metaphor
CSCL	Computer – Supported Collaborative Learning
DP	Design Principle
IMIA	International Medical Informatics Association
CMIO	Chief Medical Information Officer
ICT	Information Communication Technology
VLE	Virtual Learning Environment
LMS	Learning Management System
CKP	Contextual Knowledge Practices

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1 Introduction

1.1 Education, skills and work in the 21st century

“Education is the most powerful weapon which you can use to change the world”, Nelson Mandela

Today’s students live in a society where the economy demands for a higher percentage of workers with superior skills and learning capabilities [1]. Due to globalization, technology, migration, international competition and changing markets [2][3], students will have to tackle jobs profoundly dissimilar from the current ones; for example, outsourcing and entrepreneurship involve competences that are typically not taught in higher education [3]. In order to manage effectively these changes, new types of competences are required which represent modern knowledge work practices, such as critical thinking, problem solving, collaboration and leadership, agility and adaptability [4][5].

The European Framework for Key Competencies for Lifelong Learning has recognized eight key competences essential for individual satisfaction, functional citizenship, social inclusion and employability in a knowledge society, and which many countries use as a reference point [3]. These are the following:

- “1. Communication in the mother tongue;
2. Communication in foreign language;
3. Mathematical competence and basic competences in science and technology;
4. Digital competence;
5. Learning to learn;
6. Social and civic competences;
7. Sense of initiative and entrepreneurship;
8. Cultural awareness and express.”

There has been significant progress in adapting school curricula in order to prepare students for work, citizenship and life in the 21st century. For example,

Table 1-1, synthesizes some of the worldwide reforms in education systems for developing the skills, knowledge and attitudes necessary for success [4]. Research however indicates that pedagogical changes have not been realized as estimated [4] and curricular transformation as a mean of change, has not been sufficient [3].

Table 1-1: How education systems are addressing 21st century skills

Country	Year	Approaches
Hong Kong	2000	Learning to Learn reform, addresses applied learning and “other” learning experiences, including service and workplace learning.
Japan	2006	Zest for Living education reform, stresses the importance of experimentation, problem finding, and problem solving instead of rote memorization.
China	2010	Greater emphasis is placed on students’ ability to communicate and work in teams, pose and solve problems, and learn to learn.
Finland	2010	New focus on “citizen skills”: (a) Thinking skills, including problem solving and creative thinking; (b) Ways of working and interacting; (c) Crafts and expressive skills; (d) Participation and initiative; and (e) Self-awareness and personal responsibility
Singapore	2010	New Framework for 21 st Century Competences and Student Outcomes is intended to better position students to take advantage of global opportunities.
United States	2010	Common Core State Standards initiative, redefines standards to make them inclusive of rigorous content and applications of knowledge through higher-order skills, so that all students are prepared for the 21 st century.

Source: Teaching and Learning 21st Century Skills from the Learning Sciences [4]

According to Rosefsky Saavedra and Opfer, three are the reasons why this is happening. First, in majority of the world, the main approach to compulsory education is still the transmission model, through which students gain factual knowledge through lectures and textbooks but have little opportunity to apply this knowledge to new and more complex contexts. Second, students do not learn skills if they are not explicitly taught. And third, such skills are more difficult to assess in the classroom the way it is organized and assessed, in comparison to factual memorization skills [4].

Moreover, research run in the connection between education and labour, especially at the tertiary level, comes to verify that there is a gap among the knowledge required at work and knowledge and skills produced throughout education [6][7][8]. This gap between what industries expect and what education delivers is not caused by lack of content. It is caused by a failure to deliver prospect for imagination, cooperation, context and concrete applications. The “one-size-fits-all” concept of education needs to be modified as more and more students feel unprepared to meet the challenges of the 21st century workplace [5].

According to European Union, education should become more flexible and related to the requirements of the labour market [3]. More original approaches to teaching and learning need to be established and applied on a broader basis [9]. The methodology of teaching and assessing knowledge and skills should accommodate not only different learning styles but also the demands of a knowledge society [5].

1.2 Trialogical Learning

Trialogical learning is a pedagogical approach that has been developed and investigated by a large project called the Knowledge Practices Laboratory (KP-Lab). The project’s duration was for five years (2006-2011) where 20 partners from 14 countries participated, and had a basis on their ideas around the *knowledge creation metaphor* of learning (KCM) [10][11].

Three Metaphors of Learning

In 1998, Sfard distinguished between two metaphors of learning in order to explain how learning happens, the *acquisition metaphor* (AM) and the *participation metaphor* (PM) [12][13].

According to the acquisition metaphor, learning is a process happening in the individual mind for the purpose of developing concepts and acquiring knowledge

[13]. “Hence, knowledge is understood as a property of an individual mind, in which learning is a matter of construction, acquisition, and outcomes, which are realized in the process of transfer” [14]. For the participation metaphor, learning is a process through which someone becomes part of a community [13]. “The focus is more in activities (‘knowing’) rather than on outcomes or products (‘knowledge’)” [14].

Therefore, while in acquisition metaphor the emphasis is on the individual mind and how it learns, in participation metaphor the emphasis is on the activities of an individual interacting with a community. Despite the differences, Sfard stressed that the metaphors do not exclude each other. On the contrary, we need both of them in order to fully understand how learning happens [12].

Today though, we live in a modern knowledge society which is characterized by: 1) the rapid progress of technology which forms new methods of interaction and collaboration, 2) the force to build new knowledge and alter current practices in several areas of life, and 3) the complexity of the society which forces people to combine their expertise with others in order to solve complex, often unforeseen problems [11]. Since neither of the two metaphors is enough to explain the processes of deliberate learning and knowledge advancement as they happen today [13][15], in 2004, Paavola, Lipponen and Hakkarainen felt the need to introduce a third metaphor of learning, the *knowledge creation metaphor* (KCM) [14].

The knowledge creation metaphor has a basis on theories emphasizing collaborative creativity and it was first developed in the context of computer-supported collaborative learning (CSCL) [11]. Learning is seen as a process of novel study targeting at the gradual progression of knowledge and deliberate alteration of societal practices [15].

Therefore, if the acquisition metaphor represents a “monological” view on human cognition, where things happen individually in the human mind, and participation metaphor represents a “dialogical” view where interaction with others is emphasized more, the knowledge creation metaphor represents a “trialogical” approach because the emphasis is not only on individuals or the community, but also on the way that people cooperate to develop mediating artefacts (see Figure 1-1) [13][14].

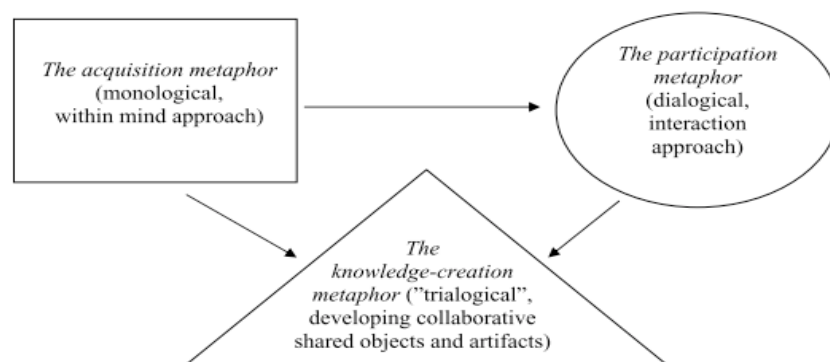


Figure 1-1: Three metaphors of learning

Source: The Knowledge Creation Metaphor – An Emergent Epistemological Approach to Learning [16]

Metaphors of Learning and Technology

The three metaphors of learning have been associated with different forms of ICTs depending on their scope (see Figure 1-2).

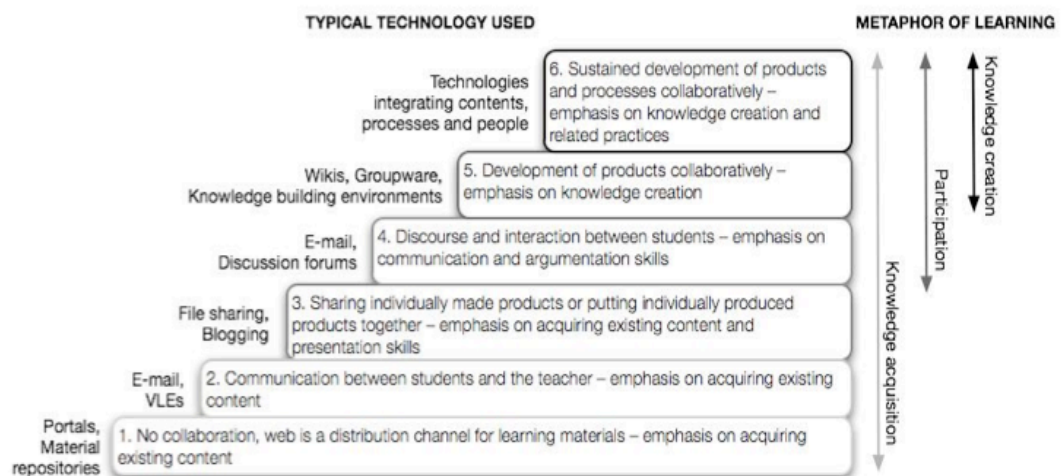


Figure 1-2: Steps of web-collaboration during education

Source: Knowledge Practices, Epistemic Technologies, and Pragmatic Web [15]

The knowledge and participation metaphor have been correlated more with technologies whose functionalities are limited to information distribution and plain involvement in social communication [15]. Such examples are portals, emails, Virtual Learning Environments (VLEs), file sharing, blogging, email and discussion forums where emphasis is given more on acquiring content, on communication and argumentation skills.

On the other hand, due to its nature and scope, the knowledge creation metaphor has been associated with technologies that assist continuous efforts of knowledge development [15]. The ICTs it has been correlated with provide the possibility to integrate contents, processes and people and exploit environments where knowledge creation can prosper.

Triological Learning and Design Principles

In order to represent the knowledge creation metaphor in practice, in relation to technology-enhanced learning and through a particular approach, KP-Lab developed the *Triological approach* of learning [11]. “In Triological learning, the focus is not just on the learners (emphasized on the acquisition metaphor) nor just on social processes (emphasized in the participation metaphor), but also on a third element; that is on jointly developed ‘objects’ (knowledge artefacts, processes or practices) that are built through the help of flexible digital tools, meant for some later use” (see Figure 1-3) [10][16][17].

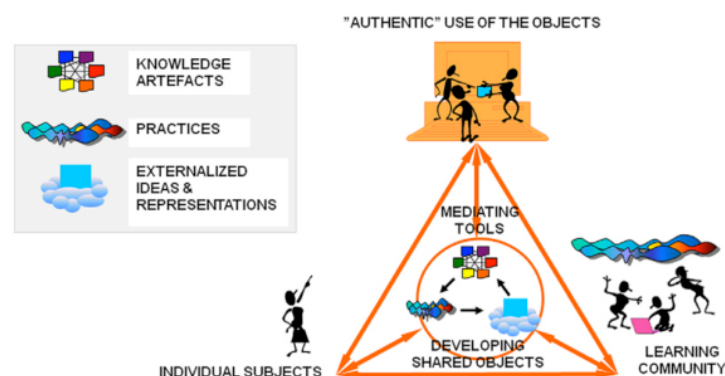


Figure 1-3: Illustration of the Triological Approach of Learning
Source: Investigating Knowledge Creation Technology in an Engineering Course [17]

To best explicate the central ideas and features of the Trialogical approach of learning, KP-Lab project developed a set of design principles (DPs) according to which someone can start applying Trialogical learning. The DPs are presented on Table 1-2 with DP1 (design principle 1) and DP6 (design principle 6) being the most prominent ones [11][18][19]:

Table 1-2: Design Principles

DP1 – Organize activities around shared “objects”
<ul style="list-style-type: none"> • Organize students’ activities during courses and assignments so that they can work on and improve a shared object • The shared object may be plans, reports, models, products, concepts, prototypes etc. • Work is advanced through cycles of shared planning, brainstorming, making drafts, getting feedback, improving, presenting and delivering/publishing
DP2 – Support integration of personal and collective agency and work
<ul style="list-style-type: none"> • Combine participants’ own interests and shared tasks • Coordinate individual and collective activities • Learn collective responsibility and agency
DP3 – Emphasize development and creativity through knowledge transformation and reflection
<ul style="list-style-type: none"> • Examine knowledge in various forms • Apply declarative and conceptual knowledge in practical problems • Explicate tacit knowledge • Reflect on collective practices and knowledge
DP4 – Foster long-term processes of knowledge advancement
<ul style="list-style-type: none"> • Build on previous achievements • Make several iterations of products and artefacts to improve them • Plan use for the outcomes • Extend idea development across courses and forums
DP5 – Promote cross-fertilization of knowledge practices and artefacts across communities and institutions
<ul style="list-style-type: none"> • Students collaborate with professionals in the field • Students and teachers from various backgrounds and domains collaborate on solving a shared problem • Expert practices are modelled for students via templates and tools • Professionals, teachers and students share and reflect on the practices, why and how?
DP6 – Provide flexible tools for developing artefacts and practices
<ul style="list-style-type: none"> • Tools that support integrated organization of collaboration and coordination • Tools that support forming a learning community and interaction • Tools that support co-construction of shared artefacts and practices • Tools that enable analysis and reflection on collective practices

1.3 Health Informatics

“If physiology literally means ‘the logic of life’, and pathology is ‘the logic of disease’, then health informatics is the logic of healthcare”, Enrico Coiera,

Definition of health informatics

Defining health informatics has been a controversial issue on the field since there exist several definitions and there is even a difficulty on deciding on the adjective in front of the term informatics (i.e. medical, biomedical, health) [20][21]. For the purpose of this thesis the term health informatics is going to be used. The following definitions explain as simply as possible what health informatics is and the role of the practitioner on the field.

According to the International Medical Informatics Association (IMIA), “Health informatics is defined as the discipline dealing with systematic processing of data, information and knowledge for optimal decision-making in medicine and healthcare” [22] or as Coiera defined it “Health informatics is the study of information and communication systems in healthcare” [23].

A clearer definition of the term came from Hersh, who raised the need for discussions on further defining the discipline, according to whom “Health informatics is the field that is concerned with the *optimal use of information, often aided by the use of technology, to improve individual health, health care, public health, and biomedical research*. The practitioners of informatics are usually called *informaticians* and view their focus more on information than technology” [24].

In simple words, the scope of the health informatics discipline is “To improve health outcomes and healthcare system efficiency” and Figure 1-4 depicts a summary of that [25].

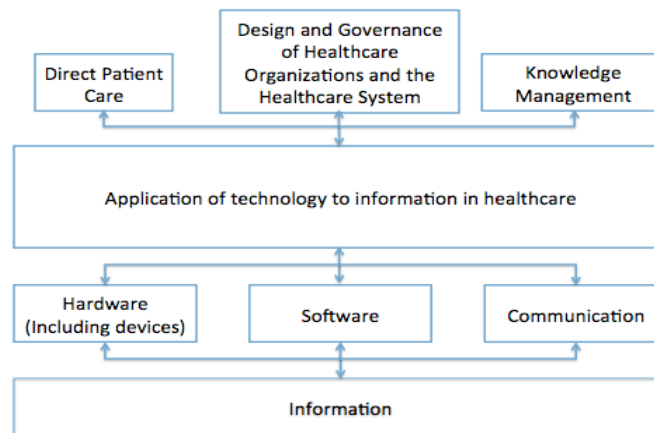


Figure 1-4: Scope of health informatics discipline

Health Informatics Education

Research has shown that health informaticians do not have a clear professional identity making it harder to define the set of skills or knowledge they should obtain during their education to successfully enter the work industry [21][24][26]. IMIA tried to overcome this challenge firstly in 2000 and later through a revision in 2010 by providing a set of recommendations in health and medical education.

According to IMIA’s revised recommendations [20], a health informatician should have “knowledge/skills in three domain areas:

- a) Methodology and technology for the processing of data, information and knowledge in medicine and healthcare,
- b) Medicine, health, biosciences, and health system organization, and
- c) Informatics/computer sciences, mathematics and biometry”

Following these recommendations, a general inclination towards building the health informatics curriculum has been to integrate disciplines correlated to the field since they share mutual knowledge, methods and tools. This has been to ensure that graduates acquire the essentials of the associated disciplines and provides them with the possibility to focus on more than one area during their studies (see Figure 1-5) [20].

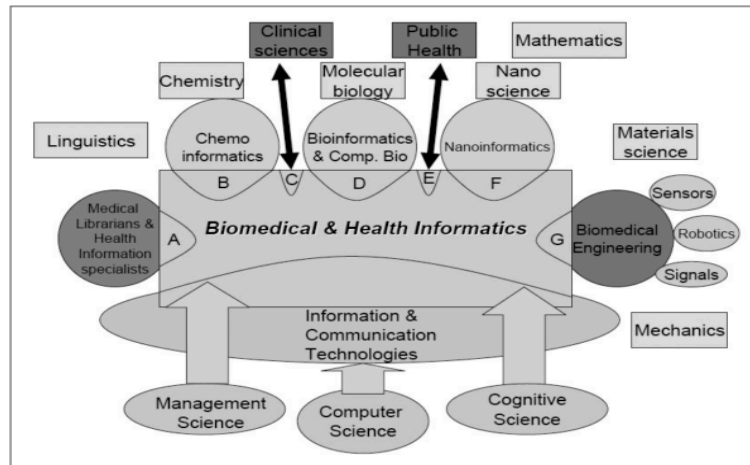


Figure 1-5: Health informatics and related fields

Source: Recommendations of the IMIA on Education in Biomedical and Health Informatics [20]

As far as skills and knowledge are regarded, most current graduate health informatics programs have placed more emphasis on building competencies in data processing, knowledge in healthcare and computer sciences with decision support, clinical information management, database design and other computer skills being rated highly by most institutions [21][27].

Research though indicates that technical skills are not always higher in the preference of the employers and disciplinary knowledge itself does not guarantee a job for the new graduates [28]. According to a survey conducted by Hoffman and Ash to 1000 randomly selected potential employers of informatics graduates, regarding the preferred skills of graduates of medical informatics programs, knowledge work practices related with organizational and interpersonal skills were ordered in a higher ranking than the technical qualifications [26][29].

Furthermore, it is gradually acknowledged that a competent health informatician should have knowledge not only of information technology but also in non-technical disciplines such as healthcare organization, business and management [21][30]. According to a study conducted to health managers, as cited by Hersh, it has been found that they had a higher inclination towards employees with clinical experience, understanding of healthcare and solid communication skills [21][30].

An analysis carried out at Chief Medical Information Officers (CMIOs) showed that skills such as leadership, negotiation, conflict resolution and management were also considered very important for being successful over the technical skills [21][30][31]. Interpersonal skills, communication skills, comprehension of organization strategy and of senior management in IT/information management planning are knowledge work practices highly requested in positions that a health informatician could take over [27].

1.4 Research Problem Summary

Students today live in a knowledge work society where the emphasis is increasingly set on the ability to create new knowledge in collaboration with others and being able to handle complex artefacts [32]. It is crucial that program developers in health informatics education, are alert of the current drivers in the society [21] and develop their programs aiming at relevant knowledge work practices [33].

What is more, there is an increasing need to know how new knowledge and practices are created in today's knowledge society [14]. Health informatics students should be adequately exposed to real-world health problems and systems during their studies in order to successfully approach such issues and get the necessary experience and knowledge to enter the industrial world [34].

Also, finding out what students' expectations and needs are towards knowledge work practices in health informatics education could be of great benefit both for them and their institutions. It is essential that education in health informatics is built in a way that provides the students with the best they can get throughout their studies and makes them feel more confident in their future roles as health informaticians.

By organizing education within health informatics to target modern work practices, could be a way of preparing students to understand the changes in the society [14] and become competent in their future jobs. This is essential taking into consideration the need for an effective education and training in the health informatics field [21]. After all, research has shown that successful health transformation can be best achieved through highly competent workforce and education could be the mean for achieving this [30][34].

1.5 Aim of the study

This study involves the following two aims:

Aim 1: To investigate students' and teachers' views and expectations on knowledge work practices in health informatics education.

Objectives for Aim 1

- To identify students' and teachers' views and expectations on knowledge work practices

Aim 2: To investigate to what extent can the Trialological approach of learning be implemented in health informatics education.

Objectives for Aim 2

- Identify teachers' perspectives on the design principles of Trialological learning
- Adapt a course by integrating Trialological learning into it in order to expose health informatics students and teachers in this approach of learning
- Explore the students' and teachers' views on the implementation of the Trialological design principles

1.6 Research questions

The main research questions this project should answer are:

- Q1: What are the students' and teachers' views and conceptions of or expectations on knowledge work practices in health informatics education?
- Q2: To what extent can the Trialogical approach of learning be applied in health informatics education?

The sub questions related to Q2 are the following:

- Q2.1: How can a Trialogical approach of learning be applied in a certain kind of course and what should be avoided?
- Q2.2: What are the lessons learnt from the chosen implementation?
- Q2.3: What seemed to work and what not?

2 Methods

"If you want truly to understand something, try to change it" Kurt Lewin

2.1 Research Methodology

Research can be defined as "any sort of careful, systematic, patient study and investigation in some field of knowledge" and a major distinction is whether it is applied or basic research [35]. This thesis falls in the category of applied research, as the main purpose was to explore the application of a novel educational approach in education. More specifically, this study investigated the degree to which the Trialogical approach of learning could eventually be applied in a master course in Health Informatics, by collecting students' and teachers' views and expectations towards knowledge work practices in health informatics education before, throughout and after its implementation.

2.2 Research Approach and Study Design

Taking into consideration the nature of this study, a different research approach and study design for each of the research questions set was followed. For the first research question, a qualitative research was conducted where data were collected through structured and semi-structured interviews and open-ended web questionnaires to explore the students' and teacher's views and expectations towards knowledge work practices in health informatics education. The reason for using such an approach is that it could provide more thorough and rich perspectives from those experiencing it [36] and by documenting participants' replies through a narrative form over time could help to best understand such facts [37].

To address the second research question, a mixed-methods approach combining both quantitative and qualitative methodologies was used. The qualitative data were collected through structured interviews, standardized open-ended group interviews, non-participant observations and the quantitative data was collected through a standardized closed-ended web questionnaire.

The study was conceptualized by utilizing Triangulation as a strategy in order to provide a more complete picture of the study and used the Embedded Design, where the following procedural notation was followed [38]: qual -> QUANT. That is both qualitative and quantitative data were collected, with the qualitative data playing a supportive role to the quantitative ones. The quantitative data were best on recording the outcomes of the research intervention, while the qualitative data were best on identifying how participants experienced it throughout the process, providing therefore answers to the qualitative sub questions that were related to the main qualitative research question. [35]. The rationale for using such an approach is that such designs are useful in order to verify or cross-validate study findings by providing a greater understanding of the phenomenon of interest [38] since “the strengths of the two methods complement each other and offset each method’s respective weaknesses” [35].

2.3 Study Context

The study was carried out within the framework of a European Project called KNORK (Promoting Knowledge Work Practices in Education). “KNORK project builds on a need for easily applicable pedagogical approaches supporting novel knowledge work and digital competences in education. The pedagogical models and supportive technologies that are to be experimented are refined in four countries across Europe (Bulgaria, Finland, Italy and Sweden)” [39].

The results of this study derived from the Swedish context. Through the study the students’ and teachers’ perspectives towards knowledge work practices in education in Sweden were explored and a course setup from tertiary education was used as an example to explore the applicability of a novel approach of learning in that setting. More specifically, a course in health informatics was purposefully adapted according to the Trialological approach of leaning in order to explore the applicability of its design principles in real educational settings.

2.4 Study Participants and their recruitment

Since KNORK project was interested in exploring the implementation of the Trialological learning in a tertiary level in the Swedish context, it was decided to conduct the study in Sweden. Due to time limits and no possibility of selecting a sample of individuals from all students and teachers in Sweden (as they are diverse and scattered in a large geographic area), the method of convenience sampling was used. “A convenience sample is a group of individuals who (conveniently) are available for study” [35]. The main advantage of this method is convenience but then the convenience sample will likely be biased and cannot be considered representative of the population [35].

The selection of the participants for this study was done from a convenience sample consisting of a group of first year (n=23) and second year (n=18) master students studying health informatics and teachers (n=2) teaching health informatics courses in Karolinska Institutet in Stockholm who were available for study. The teachers were first approached in order to investigate which of their courses could eventually be modified according to the needs of the study.

Taking into consideration the purpose of the study (which was about promoting a novel educational approach), its complexity (the need to adapt the course) and the time limits (the study had to be arranged for a certain period), only one course from one teacher fit best and only this teacher was recruited and her course was decided to be modified according to the Trialological learning. As soon as the teacher agreed to participate in the study, all first year master students, participating in the course, were approached through a web questionnaire where they were informed about the purpose of the study. Their consent to use their data results for the research was asked and demographic data, study skills and knowledge work practices expected from the course were collected. Out of the 23 students only 10 agreed to participate in the study and whose demographic data can be seen in Table 2-1.

Table 2-1: Participants' demographic data (Students), n=10

Participant	Gender	Age	Background
S1	Male	27	Technical
S2	Male	29	Technical
S3	Male	26	Technical
S4	Female	35	Technical
S5	Female	27	Technical
S6	Female	29	Medical
S7	Female	45	Medical
S8	Female	38	Medical
S9	Male	28	Medical
S10	Male	26	Medical

2.5 Course Context

The course where Trialological learning was applied is called Case Studies in health informatics. Case Studies, is a compulsory course in the domain of health informatics, targeted at first year health informatics students in Karolinska Institutet, Sweden. The course offers an introduction to the case study pedagogy, continuing with the studying of four case studies related to health informatics. Only two hours of instruction are provided in the beginning of the course and where the teacher shows to the students the different ways of tackling case studies and then students are expected to use the learning material and work individually on their own in order to provide their solutions to the cases.

The cases describe health informatics scenarios and are explained in written text. Each case lasts for four weeks and during that time students are expected to analyse them individually in a case essay. Each case is treated in a seminar that is held in the end of a four week period and where students discuss the case and all of them are expected to be able to explain their analysis orally [40].

It can be seen that the course is designed in a way that learning first happens individually (in the minds of the students since they are required to read a case study and provide an analysis of the case individually) and then it happens by interacting within the class (since students have to participate in the case seminar where they discuss altogether the case). Emphasis is given on the individual development of a non-shared object (case essay/digital solution) and where learning can be seen as a “monological” and “dialogical” process but not a “trialogical” one as this project would like to promote.

Course Preparation

Considering the nature of the Case Studies course and the dates it was run, it was decided that there was enough room for modification in order to organize the final two remaining case studies according to the Trialogical approach of learning. A workshop was conducted with the teacher in order to explain more thoroughly what Trialogical learning is and the design principles under which it is based. The importance of design principles 1 and 6 in Trialogical learning was emphasized throughout the workshop, and therefore it was decided to put more effort on applying them in the course. In order to realize them, it was found necessary to build the cases in a way that would organize activities around shared objects and the shared artefacts and practices could be developed through the use of flexible digital tools.

Since the last two cases involved the development of a digital prototype on top of the case essay, the teacher, agreed to make the nature of the cases collaborative as far as the digital solution was concerned (the digital prototype became the shared object) and to integrate flexible technologies whose purpose would be to help students build their solutions collaboratively and manage their group work in an easier way.

Later, in collaboration with the teacher, a guide to conduct the last two case studies according to Trialogical learning was set up by following a template for

planning and describing pedagogical scenarios provided by the KNORK project. The final version of the guide, which was prepared for the purpose of the two last case studies, can be seen in Appendix A. According to the guide, students had still to write an individual case essay but they had to build a digital prototype solution in groups for each case study and use certain digital tools that according to their functions, were assumed to promote collaboration, project management and interaction like Trialogical learning proposes.

Table 2-2 shows a summary of the differences between the first two cases studies (that where organized without the Trialogical approach) and the last two case studies (that where organized according to the Trialogical approach), as far as the design principles (DPs) were concerned.

Table 2-2: Case Studies Comparison, n=4

Trialogical learning DPs	Case Studies without Trialogical learning approach	Case Studies with Trialogical learning approach
Organizing Activities around Shared Objects	x The case studies course involved individual case essays and there were no shared objects to organize activities around.	✓ The case studies course involved individual case essays but now students had to build a digital prototype solution (shared object) in groups for each case study.
Supporting Integration of Personal and Collective Agency and Work	x There were no groups to support collective work. The cases were solved individually and therefore they only supported the integration of personal work during the case seminars.	✓ The cases were dealt in groups to provide a prototyping solution where students with different backgrounds where mixed. Through this way students were given the possibility to integrate personal and collective work in their group work too.
Emphasizing development and creativity through knowledge transformations and reflection	x Students followed predefined templates to write their individual reports. There was little opportunity for knowledge transformation and reflection throughout the seminars.	✓ The digital tools that students were asked to use during their group work offered the possibility to transform knowledge in a creative way and also students were expected to reflect on their team work through the individual essays and the seminars.
Fostering long-	✓	✓

term processes of knowledge advancement	Students had the opportunity to revise their case essays after each case seminar and use the knowledge of case pedagogy and prototyping in other courses in their second year.	Students had the opportunity to revise their case essays and digital solution after each case seminar and use the knowledge of case pedagogy and prototyping in other courses in their second year.
Promoting cross-fertilization of knowledge practices and artifacts across communities	<p style="text-align: center;">x</p> <p>Students worked in real health informatics cases but there was little opportunity to collaborate with professionals or other external communities related to the case study subject.</p>	<p style="text-align: center;">x</p> <p>Students worked in real health informatics cases but there was little opportunity to collaborate with professionals or other external communities related to the case study subject.</p>
Providing flexible tools for developing artifacts and practices	<p style="text-align: center;">x</p> <p>The only tool students were provided, was a Learning Management System (Ping Pong) through which they could download the course material and communicate in a forum with the class but no further collaboration or interaction could happen due to the nature of the cases that needed to be solved individually.</p>	<p style="text-align: center;">✓</p> <p>Except for Ping Pong, students were provided with three digital tools whose purpose was to promote collaboration, interaction, communication, project management and creativity in the group work. The tools were chosen according to a set of criteria that promoted trialogical learning (the criteria are explained in the following section).</p>

Digital Tools Justification

The technology that was used in the two first case studies was a Learning Management System called Ping Pong and whose functionalities can relate more to the technologies associated with participation and knowledge acquisition as described on steps 1,2,3,4 in figure 1-2. Since the course was adapted according to Trialogical learning, the need to find the technology that supports its application was considered important (Design Principle 6 is the second most important principle after Design Principle 1). Research on the Internet followed up to find a flexible digital tool that could enhance collaboration, progressive and deliberate development of knowledge, and development of a shared object in social communities.

Unfortunately, due to time and economic constraints, it was not easy to find only one tool that could provide the desired described elements altogether. To overcome this obstacle, it was decided to use a combination of free digital tools which if combined, for different purposes throughout the development of the digital prototype, they could offer the desired elements, even though separately. The tools that were chosen were Padlet, Popplet and Trello and Table 2-3, provides a small description of their main functionalities.

Table 2-3: Digital Tools Short Description

Digital Tool	Short Description	Link
Padlet (Digital Wall)	Padlet is a free tool, which can be used collaboratively by many people in the same time. It is actually a digital wall where anyone can put a post on it and then organize these posts according to the categories they belong. Also someone can post on this wall images, links, documents etc. It is an interesting tool that can promote collaboration and innovation through an innovative way.	http://padlet.com
Popplet (Mind Mapping)	Popplet is a free tool that can be used collaboratively by many people in the same time. It is a tool that helps mind map and organize your ideas through popplets, and which can be edited according to the users' needs. Users can add in the popplets images, links or even draw in them.	http://popplet.com
Trello (Project Management)	Trello is a free collaborative project management tool that can help users manage their projects by organizing them into boards. In these boards the users can add other users and assign activities or resources and see what needs to be done and who is working on what and until when.	https://trello.com

The chosen tools followed the characteristics that flexible tools should have, according to the way that knowledge creation metaphor and Design Principle 6 recommend (a synopsis of these characteristics can be seen in Table 2-4). The rationale for assigning the following characteristics to each tool was based on research and trial on the functionalities they offered.

Table 2-4: Digital Tools Characteristics, n=3

Characteristics	Popplet	Trello	Padlet
Collaboration	✓	✓	✓
Coordination		✓	
Community Formation (Integration of people)	✓	✓	✓
Interaction		✓	✓
Co-construction of shared artefacts (integration of objects)	✓		✓
Co-construction of shared practices (integration of practices)		✓	
Analysis	✓		✓
Reflection	✓	✓	✓
Knowledge building environment	✓	✓	✓

- Due to its flexibility and simplicity, Popplet was chosen as a mandatory tool through which the groups could visualize the problem description and justify their digital solution through the utilization of a mind map.
- Trello was suggested as a non-mandatory project management tool through which students could make a project plan on how to deal with the case and assign roles to the group members.
- Padlet was suggested as a non-mandatory digital place where the team members could share resources and build their ideas on digital walls.

2.6 Study time frame

The study was carried out from February 2014 until May 2014 and it can be separated into four phases. The time frame is summarized in Figure 2-1.

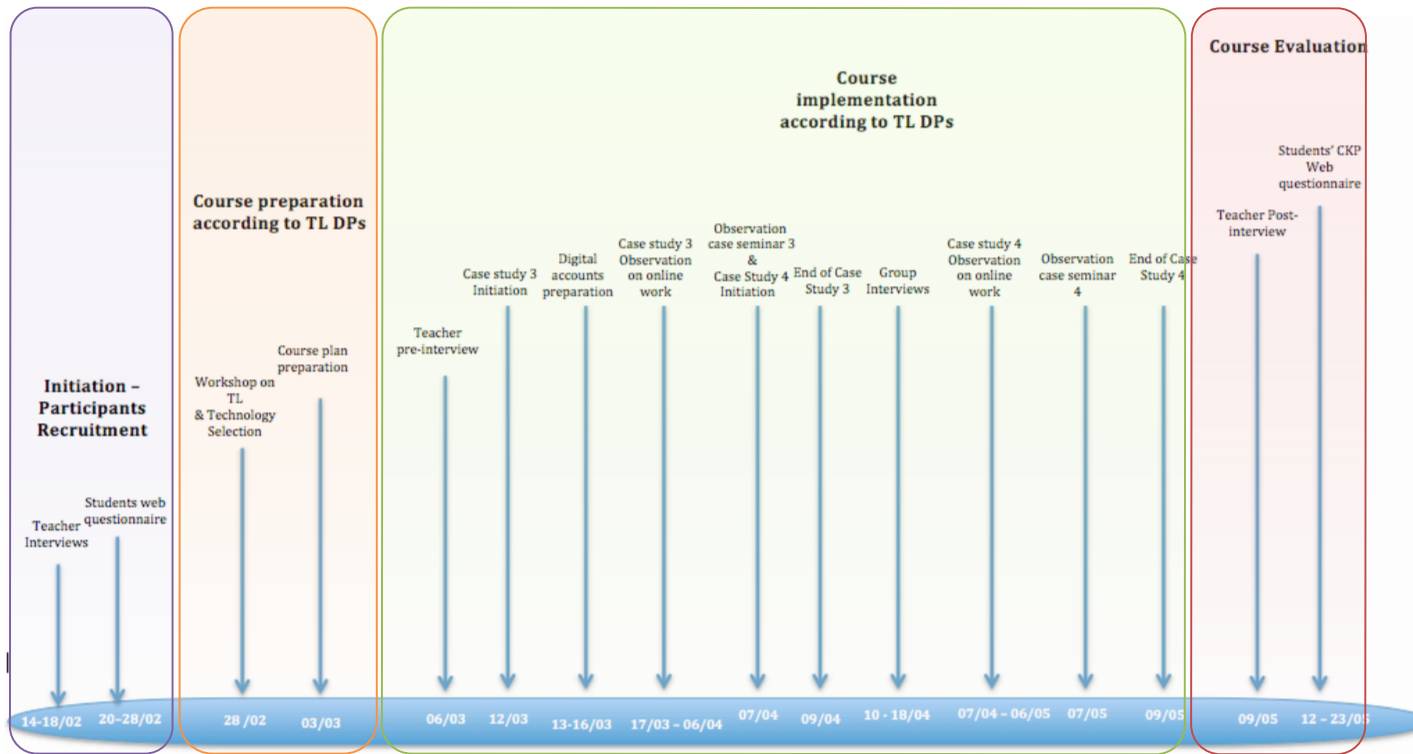


Figure 2-1: Research Study Time Frame

Phase 1 – Initiation-Participants Recruitment (February 2014)

During phase 1, participants were recruited for the study. An interview was conducted to the teacher to find out more about the course and her expectations towards knowledge work practices in health informatics education. The students, who participated in the chosen course, were approached through a Web Questionnaire in order to recruit them by informing them for the purpose of the study and finding out more about their expectations towards the course goals and knowledge work practices.

Phase 2 – Course preparation according to Trialological learning Design Principles (DPs)

In order to prepare the course according to Trialological learning DPs, a workshop was first conducted with the teacher in order to introduce her more thoroughly to the Trialological approach of learning. Next step was to adapt the course by integrating Trialological learning into it based on the DPs of Trialological learning and certain technological tools to support the course activities were chosen.

Phase 3 – Course implementation according to Trialological learning DPs

In total the course consisted of 4 case studies and Trialological learning was implemented on cases 3 and 4. Before the cases begun a pre interview with the teacher was conducted in order to see her expectations towards the implementation of Trialological learning in her course. Students then were asked to create groups under which they would work on the cases. For each group, the virtual spaces and tools were prepared and accommodated. Observations on the students' online work and throughout the case seminars were carried out during case study 3 and 4. A group interview was conducted in the end of case study 3 in order to explore how students worked under the adapted course.

Phase 4 – Course Evaluation

When the fourth case study finished, the evaluation phase followed. In the evaluation phase it was important to assess the degree to which the DPs were eventually implemented in the case studies. Therefore, a post interview was carried out with the teacher in order to explore the degree to which her expectations were eventually met. A final Contextual Knowledge Practices (CKP) questionnaire was released to the students to assess quantitatively the degree to which the DPs were applied throughout the case studies.

2.7 Data acquisition and measurement

Data were collected in two levels during the study since data acquisition was applied both to the teacher and to the students participating in the modified course. Table 2-5, shows a planning matrix for the research where different data were collected from different participants (teacher and students) for every phase of the research, serving a different purpose.

During Preparation phase no data was collected but some data gathered from Initiation phase helped to organize the events that took place during the Preparation phase. The qualitative data that were collected throughout the Implementation and Evaluation phases were used to provide answers to the sub questions related to the second research question while the quantitative data provided a basis for answering quantitatively the second research question. (Table 2-6 offers a more detailed description of the data that were collected).

Table 2-5: Planning matrix for research, n=11

Sample	1. Initiation (1 month)	2. Preparation (1 week)	3. Implementation (3 months)	4. Evaluation (1 month)
Teacher	1.1 Interview (QUAL*)	2.1 Workshop 2.2 Course plan modification	3.1 Pre-interview (QUAL)	4.1 Post-interview (QUAL)
Student	1.2 Web questionnaire (QUAL)		3.2 Observation on online work (QUAL) 3.3 Observation on seminars (QUAL) 3.4 Group Interviews (QUAL)	4.2 CKP web questionnaire (QUANT*)

* QUAL = Qualitative, QUAN = Quantitative

Table 2-6: Data Description

Data Source	Description
Teacher	<p>1.1 Semi-structured Interview to find out more about the goals, expectations and design of the course before it was modified according to Trialological learning (Appendix C)</p> <p>3.1 Semi-structured Pre-interview in the beginning of the modified course, to find out about expectations throughout its implementation according to Trialological learning (Appendix D)</p> <p>4.1 Semi-structured Post-interview to find out if the expectations were met in the end of the modified course (Appendix E)</p>
Students	<p>1.2 Web questionnaires in the beginning of the course to find out about demographic data and their expectations on the course before it was modified according to Trialological learning (Appendix F)</p> <p>3.2 Observation on online work on the modified course according to Trialological learning for the following tools:</p> <ul style="list-style-type: none"> • Popplet: Mind map creation and collaboration • Padlet: Digital wall interaction, files uploaded, digital wall structure • Trello: Project management, files uploaded, roles association, group interaction <p>3.3 Observation on the two last case seminars (which were modified according to Trialological learning), where students presented their final products and reflected on their group work</p> <p>3.4 Standardized open-ended Group interviews in the middle of the modified course to find out about team work and interaction with the technology; four teams with at least one study participant present (Appendix G)</p> <p>4.2 CKP web questionnaire in the end of the course to assess the degree to which the Trialological learning design principles were eventually applied in the modified course (Appendix H).</p>

Qualitative Data

a) Interviews

A qualitative interview, is an interview throughout which the researcher inquires open-ended queries to one or more participants and records their replies [41]. Through interviews it is easier to find out how participants feel or think in a more detailed way [35]. The interviews that were carried out throughout this study were mainly one-to-one semi structured qualitative interviews that were conducted to the teacher whose course was to be modified according to Trialological learning. A standardized open-ended qualitative group-interview was conducted in the end of case study 3 to the students participating in the study.

b) Web Questionnaire

A questionnaire can include open or closed ended questions related to the purpose of the research. In the beginning of this study, a web-based questionnaire containing open and closed ended questions was released to the students since it provided a quick and easy way for data collection [41]. The questions related to demographic data were mainly closed ended questions but the questions related to expectations and goals on the course were open ended. Open-ended questions can lead to many responses that might be difficult to analyse but on the other hand they offer the participants the possibility to explain their ideas beyond the predetermined closed ended questions thus leading to clarifications and further explanations for the researcher [35].

c) Observations

According to Creswell, “observation is the process of gathering open-ended, first-hand information by observing people and places at a research site” [41]. For the purpose of this research, the role of a non-participant observer was adopted both in the students’ online work and the seminars. During the online work, throughout the observation, notes were made on how students used the tools in each case study. Throughout the seminars, notes were taken on the students’ final work (digital solution) and their reflections on working with the tools. The observations worked as complementary data on the results from the group interviews.

Quantitative Data

d) CKP Web questionnaire

In the end of the course, a Contextual Knowledge Practices (CKP) Questionnaire was released through the web to the students participating in the research. The questionnaire was created from the researchers from the KNORK project and was used under their permission for the purpose of this research. The questionnaire included certain statements that are related to the Trialological learning design principles and their format was a typical five-level Likert scale from 1 – 5, where 1 corresponds to Strongly Disagree and 5 to Strongly Agree. The purpose of the questionnaire was to assess quantitatively the degree to which the Trialological learning design principles were eventually applied in the modified cases by evaluating how much students agreed or disagreed on the applicability of the statements.

2.8 Data analysis methods

Throughout the research, different analysis methods were used on the data collected from the participants. As it can be seen from Table 2-7, for the qualitative data received from the teacher, thematic analysis was conducted. The purpose was to search, identify and describe common threads across the data without further explaining their effects. Thematic analysis was chosen as it has been suggested to be a flexible tool that can provide rich and detailed results without making further relationships [36].

For the qualitative data collected from the students, thematic and content analysis methods were followed. Content analysis was applied more specifically on the observations and the group interviews to describe the characteristics of the data by examining who said what, to whom and with what effects. The reason for using content analysis was that it could help to categorize large amounts of information and determine trend and patterns, their frequency and relationships [36].

On the other hand, thematic analysis was more helpful to analyse and reports themes within data without examining further on whom said what and their effects.

Table 2-7: Planning matrix for data analysis, n=11

Sample	1. Initiation (1 month)	2. Preparation (1 week)	3. Implementation (3 months)	4. Evaluation (1 month)
Teacher	1.1 Interview (QUAL)	2.1 Workshop 2.2 Course plan modification	3.1 Pre-interview (QUAL)	4.1 Post- interview (QUAL)
Data Analysis Method	Thematic Analysis		Thematic Analysis	Thematic Analysis
Student	1.2 Web questionnaire (QUAL)		3.2 Observation on online work (QUAL) 3.3 Observation on seminars (QUAL) 3.4 Group Interviews (QUAL)	4.2 CKP web questionnaire (QUANT)
Data Analysis Methods	Thematic Analysis		Content Analysis	Descriptive Statistics

The thematic analysis for the study was done manually and the was conducted according to the following steps [42]:

- Familiarization with the data - In this step data collected both from the teacher and the students from the interviews and questionnaires where transcribed, read in depth and initial ideas were created
- Generating initial code – Interesting features were firstly coded and then interesting data across the data set were collated to the codes.
- Searching for themes – The codes and subsequently the data were collated into the themes
- Reviewing the themes: A check if the themes comply with the codes was applied
- Defining and naming themes: A clearer definition and naming of the themes followed up after an on-going refinement and analysis

- Producing the report: In this final step, the findings of the study were presented in the themes accordingly.

The content analysis for the study was done manually and it was conducted according to the following steps [36]:

- Preparation – Read through the data to obtain a sense of the whole, a unit of analysis was selected and the content to be analysed was selected
- Organizing – Codes and categories were created, codes were grouped and compared under the categories, a description of the topics in the categories was written
- Reporting – Results are reported through categories or story line

The quantitative data, collected through the contextual knowledge practices questionnaire, had an interval format since the questionnaire included a plethora of questions following a Likert scale from 1 to 5. In order to summarize the results and group them into categories for easier analysis and representation, KNORK project members considered that a good strategy would be to position the statements to the corresponding design principles. Therefore, the data were firstly arranged into groups where a key showing which CKP statements load similarly was created, and scales were formed according to a factor analysis applied on them. The statements then were assigned to the scales and each scale was assigned to a design principle accordingly.

After requesting their permission, this thesis followed the same key that the KNORK project suggested and then an average mean analysis on the results through SPSS software followed, by using descriptive statistics to assess quantitatively the degree to which the design principles were eventually applied. The mean was chosen as the most probable value since it was best understood of the summary distributional statistics in comparison to the median and mode whom would be more useful for ordinal and nominal variables [43]. The reason for using

descriptive statistics was that it allowed the researcher to describe the material contained in many scores with just a few indices making it easier to reach conclusions [35].

2.9 Ethical considerations

Throughout the research, great consideration was given on ethical issues related to data collection and reporting [35]. Much concern was given on the application of the educational intervention in order to have as minimal disruption as possible, both for the teacher and the students. Permission to use the course for the purpose of the research was asked very early from the study coordinator and the teacher of the course where the educational approach was applied.

The adaptation of the course was carefully implemented in order to meet the teacher's goals and expectations and the students' needs and time plan. The purpose of the research was also very early made public through a web questionnaire to the students and whose consent to use their data for the purpose of the research was asked, by taking into consideration the ethical issue of data safety and confidentiality and ensuring there would be no impact on their studies for non-participation. Last but not least, permissions were asked both from the students and the teacher to record them throughout the interviews.

As far as data reporting is considered, the data was honestly reported as it was collected without altering it to satisfy certain groups or predictions. Data safety and confidentiality were strictly applied on the presented results. Instruments and studies that were completed by others were clearly stated by giving the appropriate credits.

3 Results

In this study, results related to the two research questions are presented. The research questions were the following:

Q1: What are the students' and teachers' views and conceptions of or expectations on knowledge work practices in health informatics education?

Q2: To what extent can the Trialogical approach of learning be applied in health informatics education?

The sub questions related to Q2 are the following:

- Q2.1: How can a Trialogical approach of learning be applied in a certain kind of course and what should be avoided?
- Q2.2: What are the lessons learnt from the chosen implementation?
- Q2.3: What seemed to work and what not?

3.1 First Research Question Results

To answer this research question, a thematic analysis was conducted on the teacher's first interview and to the students' first web questionnaire released in the Initiation Phase.

Teacher's first interview

Regarding the teacher, the following themes were generated:

- Theme 1 – Thoughts and expectations on the students' projects deliverables
- Theme 2 – Health informatics related knowledge work practices students should have gained by the end of the course

a) Thoughts and expectations on the students' project deliverables

According to the teacher's reply, students participating in the Case Studies course are expected to work individually on the cases and on which they would have to submit a project report and a digital prototype solution where applicable. The project reports needs to be built according to specific case methodologies and

where a proper justification needs to be provided according to the case. Students are then assessed from the average assessment of the total number of written analyses of case studies. They are expected to use the literature to support their solutions and also they are free to use any digital tools that could help them build their digital solutions where necessary.

“The cases are individual and so the reports and digital solutions. In case there is need for clarifications they can always turn to the teachers and their classmates of course”

“Students should use literature to support their reports”

“Any kind of technology that can help to build a digital solution is acceptable”

b) Health informatics related knowledge work practices students should have gained by the end of the course

The teacher expressed that throughout the case studies; students should obtain knowledge work practices related to the course goals. The following knowledge work practices are the ones that were extracted from the course syllabus [40]:

- “Knowledge and understanding
 - Ability to synthesize theoretical knowledge within health informatics
- Skills
 - Identify actors in health informatics scenarios
 - Explain and reflect on the actors’ roles and professional relations
 - Identify problems within healthcare
 - Analyse and categorize problems
 - Suggest potential health informatics solutions
 - Evaluate, suggest and recommend solutions in favour of others based on their effects
- Attitudes
 - Develop a problem, patient and clinically oriented attitude in their role as health informaticians”

Student's first web questionnaire

Regarding the students, the following themes were generated:

- Theme 1 – Experiences from previous studies on case studies
- Theme 2 – Thoughts and expectations on the current course
- Theme 3 – Health Informatics related knowledge work practices expectations

a) Experiences from previous studies on case studies

Only four out of the ten participants had an experience of case studies during their previous studies and these ones were students with a medical background. As they expressed though, this experience was quite brief and concerned only small-scale cases, which were used as exercises to explain the theory, and no further writing was required. For the rest of the participants, they mentioned that they never experienced a case study before.

“... to me, case study has been an uncharted territory ... ” (S5)

“Concerning case studies, I did not have any experience before ... ” (S9)

b) Thoughts and expectations on the current course

All the participants expressed enthusiasm on the participation on the case studies course. They thought the case studies methodology to be an interesting way of analysing and evaluating cases, especially in the health sector and expressed their eagerness on combining their previous knowledge with current knowledge to be obtained throughout the case studies course. They expressed an expectation to learn how to obtain the ability and skills to analyse cases from different perspectives together with their classmates and the teacher, and provide solutions to existing problems. Finally, they expected that the knowledge and skills they were going to obtain from the course would be directly linked with their future jobs as health informaticians.

“I would also like to learn how to analyse cases in a more structured way” (S6)

“I hope to learn how to think in my future role of health informatician while evaluating and working with these case studies” (S8)

“... I expect this course would give me the ability and skills to learn how to analyse different cases and scenarios from different perspectives (putting oneself in the shoes of others or as an outside observer)” (S9)

c) Health informatics related knowledge work practices expectations

The knowledge work practices that the participants expressed, are linked to

- Skills and abilities concerned with better analytical and evaluation skills,
- Better collaboration abilities,
- Improved writing skills,
- Better ability to solve successfully real health related challenges,
- Learn how to handle situations or plan projects according to the user needs,
- Be prepared to face real job environments in Health Informatics,
- Learn how to solve real problems with support of different Health informatics solutions and tools.

“I want to achieve a better understanding of situations that I could be presented with while on the job as a health informatician and how I can handle those situations/plan projects to better suit the needs of the intended user(s) in order to fix the problem(s) at hand” (S7)

“Develop required skills to solve challenges that really exist in health care. Especially the ones that could be addressed by Health Informatics solutions” (S1)

“Get experience from past incidents and be more prepared when I will be in a real job environment” (S2)

3.2 Second Research Question Results

To answer this research question, an average mean analysis using descriptive statistics was applied on the quantitative results obtained from the final Contextual Knowledge Practices Questionnaire released to the students during the Evaluation Phase. As far as the sub questions are related a separate analysis was conducted on the qualitative data in order to provide an explanation on how the participants experienced the course under the intervention.

More specifically, a thematic analysis was performed on the qualitative results obtained from the pre interview with the teacher during the Implementation phase and the post interview with the teacher during the Evaluation phase. A content analysis was performed on the students' group interviews and the data collected from the observations on their online work and seminars during the Implementation phase.

Quantitative Data Analysis

Contextual Knowledge Practices Questionnaire

As it has already been described, the design principles that constitute the Trialological learning are the following:

DP1 – Organizing activities around shared “objects” (e.g. plans, reports, models)

DP2 – Supporting integration of personal and collective agency and work

DP3 – Emphasizing development and creativity through knowledge transformations and knowledge

DP4 – Fostering long-term processes of knowledge advancement

DP5 – Promoting cross-fertilization of knowledge practices and artefacts across communities and institutions

DP6 – Providing flexible tools for developing artefacts and practices

Table 3-1, shows the mean average mean scores for each design principle, which were calculated from the Contextual Knowledge Practices (CKP) questionnaire.

Each question in the CKP questionnaire (from Appendix H) was assigned to one of the six design principles by using key scales, which helped to easily assign the questions to the corresponding design principles. The second column shows the results from all the participants (N=10). It can be noted that for DP1 and DP6 students agreed more on their implementation while for DP2 until DP5 students were tending to agree on their implementation. Also, regarding DP3 and DP4, it can be noticed that the results have the same score. The reason why this happened is that these DPs shared the same key for the statements in the Contextual Knowledge Questionnaire according to the factor analysis conducted from the KNORK project.

Since the participants had different backgrounds (medical and technical), a mean average score followed in order to assess the participants' results based on their backgrounds. The third column shows the results from the participants with a medical background (n=5) while the fourth column shows the results from the participants with technical background (n=5). It is interesting to notice that students with a medical background agreed more on the implementation of the DPs while students with a technical background had much lower scores with only DP6 being the highest on agreeing on the degree of implementation throughout the course.

Table 3-1: DPs Average Mean Scores

DPs	Average Mean Score from 1 – 5*	Average Mean Score (Medical Background)	Average Mean Score (Technical Background)
DP1	4.063	4.309	3.818
DP2	3.853	4.05	3.667
DP3	3.825	3.975	3.675
DP4	3.825	3.975	3.675
DP5	3.914	4.171	3.657
DP6	4.271	4.371	4.171

*Scaling of the questions from 1 – 5 where 1=strongly disagree ... 5=strongly agree

Qualitative Data Analysis

Teacher's pre interview

For the pre interview, the following themes were created:

- Theme 1 – Appropriateness of Trialological learning in the course
- Theme 2 – Differences on the implementation of the course under Trialological learning and issues of concern

a) Appropriateness of the Trialological learning in the course

All in all, the teacher found Trialological learning quite appropriate for her course taking into consideration the nature of the case studies. She found it quite hard for one person to provide an appropriate solution and design by being based on his/her own background alone and therefore by designing the course through this way could help students to provide better solutions by combining their backgrounds and previous experiences.

“Students should be able to collaborate, come up with designs and analyse problems using different perspectives. ... So, I think it is [Trialological learning] really appropriate for this course.”

“And that is really difficult to be done by one person. ... but in general students need to work collaboratively and come up with designs and also analyse problems in a genuine way.”

She mentioned that all the design principles could be covered through the course with the exception of DP5 for which she thought that it was not easy to reach that level right now but which could be applied in the future with some further organization. For the appropriateness of Trialological learning, she especially expressed that DP1 and DP6 were very applicable to the course. In general the modified course was received positively.

“And I think that design principle 1 is very applicable to the course. ... Since they [the students] are working a lot with their prototypes and analysis together, this

has to do with flexible digital tools [DP6] and organizing activities around shared objects [DP1].”

“I think that it [the modified course] is going to work very well”

b) Differences on the implementation of the course under Trialological learning and issues of concern

In the previous implementation, the cases were totally individual and there were no groups at all. Now they had to create groups through which they should conduct a group analysis and provide together a prototyping solution and there was only a report, which had to be written individually. The only concern expressed by the teacher was that some students might prefer to work individually and might not work harmoniously in the groups.

“The only thing might be that some groups might not work well together or students might be left out because they prefer to work individually.”

Teacher’s post interview

For the post interview, the following themes were created:

- Theme 1 – Design principles realization
 - Category 1 –Team Collaboration (DP1 & DP2 realization)
 - Category 2 –Technology (DP6 realization)
- Theme 2 – Challenges addressed and Future Implementation

a) Design principles realization

The general overview from the teacher was that the design principles were realized to a good degree. The tools that were proposed were used throughout the case, others more and others less. Some students used other tools too which were not proposed but they still collaborated to finish their assignments.

“I think that we got realized them [the design principles] up to a good point”

a1) Team Collaboration (DP1 (& DP2 partial realization))

The teacher expressed that team collaboration was achieved to a good point but she had heard rumours that in some groups, collaboration was not achieved as it was hoped. Also, she saw an improvement on the individual assignments in comparison with previous years. She assumed that this might have been affected from the collaboration in the group work. Having different backgrounds could have helped the understanding of the problem more deeply and collaboration might have intrigued more analysis and critique.

“I can say that there was an improvement on the individual assignment in comparison with previous year students ... students were in groups and had more time to grasp the problem and how to solve it. Having different backgrounds might have helped on collaboration and understanding of the problem more deeply”

“Better collaboration, I am not sure how we could have done it differently or in a better way.”

a2) Technology (DP6 realization)

Regarding the digital tools that were used in the cases, the teacher mentioned that Popplet received a better acceptance than Padlet and it seemed that Trello was not used at all. She assumed that the reason for not using Trello was that the problems were short and there was not such a great need for planning. According to the teacher, picking one technology for a particular type of problem might have been more suitable than having predefined technologies for all the problems.

“So, looking what technology is more appropriate for specific topics and also for specific groups, is a better way rather than using certain technological tools for all the cases”

b) Challenges addressed and Future Implementation

According to the teacher, the cases were designed in a way to promote collaboration because of the challenges faced from previous years when students had to deal the cases individually. Now, by mixing the groups with different

backgrounds helped to tackle this challenge as it provided a way to solve the problem using different perspectives and in a more thorough attitude. Also, by using technology to visualize solutions instead of just report writing, helped students make their ideas clearer, which was a problem for them and the teacher to assess in the previous years.

“I liked that students visualized their problem analysis. Which was a problem for students from last year.”

Regarding future implementation, the teacher expressed that she will continue the cases by using group work and also she mentioned that she would continue to use technology to visualize ideas and justifications.

“I will keep part of group work. ...

“Visualizing their solutions, makes it easier for them to justify their replies and also makes it easier for the teacher to assess the students”

Students’ Group Interviews and Observations

In total 23 students participated in the course, out of which 21 were active and only 10 of them decided to participate in this study. Trialogical learning was applied on case 3 and 4, and throughout which students were asked to create groups in order to provide together a solution as far as the design was concerned. A prerequisite was that each group should have at least one member with a medical background and one with technical background. In the following table (Table 3-2), the groups that were created are presented (and the study participants assigned to each group can be seen on column 3). The students created groups by themselves and the participants were randomly assigned to the groups.

Group six was the only group under which no study participants were assigned but this was not that important as the students in that group dropped out from the course in general and never participated in any activities.

Table 3-2: Student Groups, n=23

Group Number	Total Group Members	Participants in the study	Background
1	5	S1, S6	Medical: 4 Technical: 1
2	4	S10	Medical: 3 Technical: 1
3	5	S7, S9	Medical: 4 Technical: 1
4	4	S2, S3, S4, S8	Medical: 1 Technical: 3
5	3	S5	Medical: 2 Technical: 1
6	2	None	Medical: 1 Technical: 1

The group interviews were conducted to the first five groups and where at least one participant of the study from each group was present. For the group questionnaire, the following categories were created:

- Category 1 – Team Functioning (Related to DP1 & DP2)
 - Sub-category 1 - Teamwork and engagement
 - Sub-category 2 – Lessons learned
- Category 2 – Technology (Related to DP6)
 - Sub-category 1 – Popplet
 - Sub-category 2 – Padlet
 - Sub-category 3 – Trello
 - Sub-category 4 – Other tools and general comments

a) Team Functioning (Related to DP1 & DP2)

For team functioning two sub categories were created related to Teamwork and engagement throughout the case studies and Lessons learned from the students (These subcategories, are connected to DPs 1 & 2, which are about Organizing work around shared objects and Collaborative engagement and agency). For Teamwork and engagement aspects such as how Team Functioning in general was, how the teams met and collaborated, what kind of roles the members set, how they divided their work and whether they commented or revised each other's work were studied. For the lessons learned it was studied what kind of problematic aspects and good aspects students met throughout teamwork and whether they decided to work differently for the next case study based on those aspects.

a1) Teamwork and engagement

Teamwork and engagement degree from the groups (Group 1: G1, Group 2: G2, Group 3: G3, Group 4: G4, Group 5: G5) is synoptically presented in table 3-3.

Table 3-3: Groups' teamwork and engagement, n=5

	Team Function	Meetings and collaboration	Roles	Divide work	Comment or revise work
G1	Problematic	Not very often	Yes	Yes	Yes
G2	Good	Regular meetings	Yes	Yes	Yes
G3	Very good	Regular meetings	Not restricted	No	Yes
G4	Good	Regular meetings	Yes	Yes	Yes
G5	Good	Regular meetings	No	No	Yes

For G1, Team Functioning in general has been problematic as two members were not active as they were supposed to be. Due to tight schedule and the absence of the two members, meetings and collaboration were not that efficient. They met

mostly virtually and collaborated physically only when they had to design the mock-ups for the digital solution. The members who actually worked on the case set up roles and divided work according to their backgrounds and experiences. They also made sure to comment and revise their work before the actual deadline by setting up deadlines, which allowed one day for evaluation and one day for improvements.

“Only three out of five members were active which created frustrations and irritations in the team collaboration and communication” G1

“We divided the work according to our backgrounds” G1

The other groups on the other hand, commented that they worked quite well, without too many problems in general. More specifically, group three and five did not set specific roles in the group and did not divide their work. They had regular meetings (face to face and virtually) where each member contributed as much as possible and relatively equally. They also did revisions on their work together and made any changes instantly due to time restrictions.

“We had regular meetings and went through the work together” G3

“Everyone contributed relatively equally” G5

“We did not have restricted roles but we discussed as a group so that each contributed as it was required and as one was able to” G3

“We did not strictly divide the work” G5

“We went through our revisions together and made changes instantly” G3

Group two and four decided to set certain roles in the group members and also divide their work according to the backgrounds. They made sure though to comment and revise on each other's work by doing it altogether.

“We shared the work and set roles according to our backgrounds” G4

“Using our backgrounds we shared the work and made sure to revise the work altogether in the end” G2

a2) Lessons Learned

The lessons that students learned from their teamwork, are synoptically presented in table 3-4:

Table 3-4: Lessons Learned throughout teamwork, n=5

	Problematic Aspects	Good Aspects	Do Differently
G1	<ul style="list-style-type: none"> • Communication • Collaboration • Mixed backgrounds • Tight Schedule 	<ul style="list-style-type: none"> • Mixed backgrounds • Coordination 	<ul style="list-style-type: none"> • Set rules early
G2	<ul style="list-style-type: none"> • Tight Schedule 	<ul style="list-style-type: none"> • Mixed backgrounds • Good communication 	<ul style="list-style-type: none"> • Set deadlines early
G3	<ul style="list-style-type: none"> • Not Any 	<ul style="list-style-type: none"> • Each member contributed equally • Worked as a team 	<ul style="list-style-type: none"> • Try other tools too
G4	<ul style="list-style-type: none"> • Tight Schedule 	<ul style="list-style-type: none"> • Mixed backgrounds • Sharing team work 	<ul style="list-style-type: none"> • Use Scrum methods
G5	<ul style="list-style-type: none"> • Not regular physical meetings 	<ul style="list-style-type: none"> • Knew each other from before • Good communication 	<ul style="list-style-type: none"> • Meet more frequently • Set sub-goals • Set deadlines early

Problematic Aspects

For G1, the most problematic aspects have been communication and collaboration as not all members were active. Also, having mixed backgrounds was a problematic aspect for them. According to their explanation due to mixed backgrounds sometimes the members' opinions and ideas collided making it harder to provide one solution. Tight schedule was a problem for almost all of the groups making it harder to study thoroughly the case and also not meeting as often as they would like to. G3 seemed to have quite a very good team function as they did not have any certain problems throughout the case.

“Communication has been an issue. Collaboration was not easy as only three members were active” G1

“Tight schedule made it harder to meet more often” G4

“We could not meet very often physically as two members were not in the town” G5

Good Aspects

Three of the groups recognized the benefit of having mixed backgrounds for the case according to whom this fact helped to look the case in a different perspective from what they would have done if they had to face it individually. Good coordination and good communication were two aspects, which were positively considered from two groups. According to them coordinating the group work from the beginning and having good communication between the members can help to address the case in a more productive way. One of the groups appreciated the fact that they had to work in a group and share the work between the members. Finally, another group said that knowing each other from before helped them have a better communication and therefore work better as a team.

“Everyone contributed and worked together as a team” G3

“From the beginning we separated the work and that went well” G1

“... Also sharing the work in the team was good” G4

Do differently

According to the problems the teams met, they showed awareness and insight to set up future goals for the next case study. G1 for example decided to set up rules early related to communication and collaboration in order to avoid non-participation as they faced it throughout the third case study.

“Set up rules for next case study related to communication and collaboration in the group” G1

For G2 the tight schedule made them decide to set deadlines early for the handling of the next case study.

“Set deadlines early to have more time due to the tight schedule” G2

For G3, as everything went fine, they decided to try the other tools that had been proposed as they only used one of them.

“We will do the same we did for the last case but we will try the other tools that we did not use” G3

G4 decided to use Scrum methods for the next case in order to have more efficient meetings and collaboration between the members.

“Use Scrum methods to shorten meeting times in order to work more efficiently during the meetings” G4

Last G5, realized the need to meet more frequently and set sub-goals and deadlines as early as possible in order to have more time for revisions and evaluations.

“Meet more frequently ... Set sub – goals and set earlier deadlines for project completion” G5

b) Technology (Related to DP6)

The mostly used tool throughout the modified course was Popplet, with Padlet and Trello following up (See Table 3-5).

Table 3-5: Digital tools, n=3

Tools	N1*	N2**	Reasons for Utilization	Reasons for non utilization
Popplet	5	0	Mind map and visualize ideas on the case problem and solution	-
Padlet	3	2	Share resources and comments	Lack of time Did not meet users' needs
Trello	2	3	Case analysis organization and management	Lack of time Did not meet users' needs

*N1: Number of groups who use the tool

**N2: Number of groups who did not use the tool

Popplet

All the groups used Popplet, as it provided a means for mind mapping their ideas on the case studies' problems and solutions. It was found to be easy, flexible and helpful. Only one group reported to have technical issues of non-synchronization when more people used the tool simultaneously.

"We found it a really interesting and handy tool to create mind maps and put ideas in the boxes and connecting them with each other" G1

"Flexible, fast, scalable, customizable and shareable" G5

"Helped us to visualize and mind map ... However, when used to edit contents simultaneously with two different individuals, the edited content one added could not be found." G2

From the observations on the online work, it also became apparent that students used it to mind map their ideas. All of the teams, created Popplets (mind maps) by connecting ideas and solutions to the problems they had to deal for the cases. From the observations during the seminars, almost all the groups expressed their excitement for being provided with such a tool since it alleviated them from the process of reporting their rationalizations in big amounts of text.

Padlet

Padlet was used from three out of the five teams (where one team used it extensively and two used it quite simply). It was mainly used to share resources and comments through the digital wall. The two teams who did not use it explained that due to time constraints and not meeting their needs for the case studies, they decided not to use it at all.

Two of the teams who used it simply, found it hard to use it efficiently for the case studies' purpose. It did not meet too much their expectations and in the beginning they had to struggle to find out how to build the digital wall. This could also be seen on the observations done on their online work. These groups shared only a few comments and resources and there was no apparent structure on the way the digital walls were built (see Appendix I). On the other hand, the team who used it extensively built the wall in a more structured way and it became obvious how they worked in order to build their analysis and solution (see Appendix J).

Trello

Only one team used Trello in order to organize the case analysis and management. Another team who also used it said that they wanted to see how they could organize and manage their group work but limited time made it harder to use it more extensively. The others teams, said that they did not use it due to time limits and because of not finding it too useful for the case studies' needs.

Other tools and general comments

Other tools like Facebook, Skype and Google Drive were also used (G1, G4) for material sharing and communication.

One need highlighted by the groups for the digital tools that were proposed to them, was the possibility of getting instant notifications for changes. Neither of them (Popplet, Padlet, Trello) had proper notifications for the changes that took

place which created some frustrations and raised the need for better traceability of who did what.

“One thing I would like to have is notifications when someone makes changes.”

G2

This is why we used Facebook because you can instantly see any changes by anyone who did them.” G4

Also, it was mentioned that since the groups are so diverse, not one specific tool would be possible to cover everyone’s needs. It depends a lot on the tasks the group had to accomplish and with whom you would have to cooperate. Especially someone mentioned that he would have preferred to have Padlet, Popplet and Trello as one tool while another one suggested to try and use tools that offer to-do-list functionalities.

“If, e.g., Padlet, Popplet and Trello were one tool, then it would be easier to collaborate and keep track of the changes” G1

“Perhaps try additional to-do-list applications/software” G5

4 Discussion

4.1 Main findings

According to the main findings of this study, the students' and teachers' views and expectations on knowledge work practices in a certain course setting in health informatics, shared similarities but which targeted on different directions. As far as Trialological learning is concerned, it was discovered that Trialological learning was received quite well and was applied to a good extent as far as DP1 and DP6 are concerned. The qualitative data obtained from the interviews and the observations, provided more insight to the degree of application of the trialological learning in the course in comparison to the quantitative data. While the quantitative data confirmed the degree of application of the DPs, the qualitative data did the same by providing more answers to how the implementation of DPs was experienced from the participants (students and the teacher), what worked well and what should be avoided.

Views and expectations on knowledge work practices

The views and expectations from the students and the teacher participating in the Case Studies, shared many similarities. More specifically, their orientation was towards developing better skills on identifying, categorizing and analysing problems, suggesting and providing good health informatics solutions and a general ability to synthesize knowledge within health informatics projects. However, while the teacher emphasized mostly the development of skills and knowledge necessary for educational purposes, students' views and expectations were targeted more on obtaining skills and knowledge that were explicitly related to their future jobs as health informaticians. It seems important that the views and expectations of the students and the teacher are aligned to avoid the risk of disappointment and misalignment. Promoting relevant knowledge work practices throughout the case studies is an important issue for both sides.

Trialogical learning application

- **Actualization of the design principles**

From the quantitative results obtained from the participants (students) of the study, it seemed that Trialogical learning was applied to a good degree in the course. The participants agreed on the implementation of the Trialogical learning design principles, where they had higher scores as far as the implementation of DP1 (Organizing activities around shared objects) and DP6 (Providing flexible tools for developing artefacts and practices) were concerned. This did not come as a surprise, as throughout the realization of the modified course, much more emphasis was put on the implementation of those design principles. As far as the rest of the design principles were concerned, students' scores tended towards agreeing on their implementation.

On the other hand, the analysis of the results between the students with medical background and those with technical background brought to this study a surprise (see Table 3-1 for the average mean score for each background, column 3 and 4). Students with medical background had higher scores on the degrees of agreeing on the actualization of the DPs in relation to the students with technical background. This by itself could not be explained why it happened just from the quantitative data. Since, no more interviews could be conducted to explain this, an analysis of all the qualitative data that were collected through this study was done.

After a thorough analysis, an assumption was reached that the students with medical background had had a previous experience with case studies during their studies and therefore might have the ability to relate this experience with previous experiences with case studies, making it easier for them to recognize and appreciate the application of the DPs throughout the cases. On the other hand students with technical background had never experienced case studies before and especially health related ones. Therefore, it might have been harder for them to appreciate the application of the DPs the way the medical students did. DP6 was the only one they actually had a higher score than four, which means that they

managed to see its application throughout the course as they could relate it to their previous experience on the technical field.

- **Experiencing Trialological learning**

How Trialological learning was experienced, was captured through the interviews to the teacher and the group interviews and observations on the students participating in the course. All in all, since DP1 and DP2 were emphasized mostly, results from these two principles were more obvious to reflect on.

DP1 was received very well both by the teacher and the students. Taking into consideration the nature of the case studies, its realization worked mostly positively for both sides. More specifically organizing the case studies activities under a shared object (the digital prototype) was seen as an important benefit. The teacher recognized the difficulty of solving the case studies individually and also appreciated the collaboration in the groups as she assumed it helped the students to build a better individual case essay. Students managed to collaboratively work on the solution even though they faced a few problems throughout the process, which gave us more insights on what to do differently in case the implementation was repeated.

From the problems the groups faced, the need for setting rules and early deadlines throughout group work was raised. More physical meetings and set up of sub-goals were two aspects they considered important for better collaboration and coordination. The use of Scrum methods for better team collaboration was also mentioned. All these mean that a better coordination of DP1 is important in order to organize work within the groups too. It might not be enough to create groups and let them work being based on their mixed background only. The organization of the activities around the shared object might benefit more if the teacher participated more on controlling and coordinating how the functioning of the groups is throughout the case study instead of checking that during the seminars and the final deliverables of each case study separately.

The use of technology (DP6) throughout the cases was also received very well as it provided a tool for solving the cases in a faster way by visualising the problem and the solution. However, both the teacher and the students mentioned that the use of a specific predefined tool might not be useful in the same way for all the groups and cases. This surprising fact, lead us to the conclusion that a better coordination for this design principle is important too. It is not enough to find tools that have the functionalities that could support collaboration and coordination for example as it was done throughout this study.

It is important to take into consideration the nature of each case study individually and also the specific needs of each group. Maybe if certain tools are chosen to be used, a better and further training on their usage would be more beneficiary for the students rather than telling them to use them as they think necessary. An important function the tools to be chosen should have, is proper notifications on the changes that took place if someone made any alternations and also better synchronization when many members work the same time to avoid possibilities of lost work.

As far as the rest of the design principles are related, considering the nature of the case studies, their application would also be very important and careful steps should be taken to realize them. A careful planning before the initiation of the cases on their implementation would be considered necessary by closely working with the teacher of the course in order to functionally realize them.

4.2 Discussion of the methods

Alternative method

An alternative method to consider for this study would be the design-based research. Design-based research has been defined as “*a systematic but flexible methodology, aimed to improve educational practices through iterative analysis,*

design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories” [44].

Design-based research has become a popular methodology in research in education as it can deliver results that can clearly be applied to inform about educational practices in real settings [45]. Through such a research, an intervention is applied in a real setting in order to provide more insight on the goals and implications of the research [46]. In comparison to experimental studies that measure certain variables [45], design-based research focuses on understanding the practice with the context being an important element and where the participants are treated as co-researchers and not as ‘subjects’ [47]. In total design-based research is interested in capturing the social interaction, utilising multiple revisions and considers multiple variables [44][47].

The reason for not using this methodology in the present study was the limited time to implement the intervention and the limited possibility to make any revisions on the theory that was implemented throughout the case studies. What is more, the researcher needed to take into consideration many variables throughout its implementation and for the scope of this study that was not feasible due to the limitations already described.

Validity and reliability

- **Research validity and reliability**

“Research validity, refers to the accuracy and generalizability of a study’s findings and research findings are considered reliable if they can be replicated” [48]. According to Tables 4-1 and 4-2, it can be seen that in this study Internal Validity was achieved to a higher point than the External Validity. Selection bias and testing were two threats that could not be avoided in the Internal Validity and this can be associated with the way the research was designed and applied. High

external validity was not possible to be achieved as the threats were connected with aspects that could not be fully controlled by the researcher of the study.

Table 4-1: Internal validity threats

Threats		Results
Selection Bias	✓	The selection bias was not unavoidable since the subjects of the study were recruited through a convenience sample of students who were available for study. The participants enrolled themselves into the study, however these participants cannot be considered representative of the population.
Mortality	×	No mortality threat appeared, as all the participants of the study participated over time on the collection of data at multiple times.
Maturation	×	Since the study was carried out through a small scale of time, no threat of maturation appeared
Instrumentation	×	Only the researcher of the study collected the data and the procedures of data collection followed the same manner throughout the whole study ensuring no threat to internal validity.
Testing	?	The teacher of the course was exposed to the educational approach before the intervention took place through a workshop. There is a possibility that the pre and post interviews that were carried out throughout the intervention to have been affected by that and resulted in biased replies from the teacher's side regardless of the intervention. Testing on the other hand did not appear to be a threat for the students' results.
History	×	No external events caused any changes throughout the study

Symbols' explanation: ✓= Yes, × = No, ? = Maybe

Table 4-2: External validity threats

Threats		Results
Selection Effects	✓	The population validity has been affected in this study due to high selection bias created in the internal validity. Mortality and maturation did not affect the population validity on the convenience sample.
Measurement Effects	?	Maturation and instrumentation did not affect the internal validity of this study. Testing however might have affected internal validity as far as the teacher's results are concerned. No further threat from testing was seen from the students' side.
Reactive Effects	?	There is a possibility that the subjects' responses participating in the research study to have been affected throughout the study. Due to triangulation, different data were collected throughout time. The teacher's awareness of the topic was raised from the beginning and there is a possibility the students after the intervention to have replied on the interviews and questionnaires in a way that would satisfy the researcher.

As far as research reliability is considered, “research findings are said to be reliable if they can be replicated”. For example, the same methods can be used with another population or with extra variables to display that the research findings can be reliably reproduced [48]. For this study, research reliability has been higher than the research validity since the research findings were reproduced under using different variables and methods. This study can be considered valid if it is applied in the same settings, for participants with the same population characteristics and under the same educational intervention.

- **Instrument validity and reliability**

Instrument reliability is related to the instruments’ consistency [49]. The interviews and questionnaires that were used throughout this study had been already developed and tested on studies [19][45] run by the KNORK project members related to the Trialological learning. Therefore, the reliability and validity of those instruments was verified through that way. As far as the Contextual Knowledge Practices questionnaire is regarded, due to time limits to carry out further tests regarding its validity and reliability, an analysis was carried out throughout which the questionnaire was shown and tested to a few second year students in health informatics in order to check if they properly understood the statements and if a further explanation was needed to be provided on them in order to avoid as much as possible misunderstandings and misalignments.

Limitations and strengths

The primary limitation of this study is that it involved only ten participants who were recruited from a convenience sample and therefore the results cannot be easily generalized for the whole population as they express opinions of a limited number of people and also might be influenced by personal biases and preferences. Due to time limits and constraints related to the nature of the course, the study was carried out only in the last two case studies.

This is a limitation because there was no possibility to make further iterations and improvements on the modified course in order to meet the participants' needs. What is more, the first two case studies were undertaken individually, while the two last cases were solved collaboratively under the new course plan. This was a limitation for the study since it did not allow the possibility to make comparisons on how the course was first experienced and how after the intervention, as this comparison would not be valid.

As far as the results are concerned, in the content and thematic analysis the themes and categories were generated by the researcher of the study only and this might be a limitation since they (the themes and the categories) were not checked by an expert and the participants (in order to see if they agree with the given interpretations) who could provide a more valid way of generating them and therefore reaching perhaps in better analysis of the results.

The main strength of this study is the triangulation strategy that was applied. Through triangulation, different data collected from different methods were collected and it made it possible to reach to conclusions more easily rather than using a certain qualitative or quantitative method. More specifically, the qualitative data offered more insight on the sub questions set to the quantitative research question and helped to understand questions related to how and why.

The semi-structured interviews made it easier for the participants to explain their ideas and provided more rich data sets for the researcher to assess. The group interviews conducted in the middle of the study were really helpful to obtain data that regarded group work and collaboration on the participants before the study was finished, and this was important in order to assess whether the implementation of the DPs did have any kind of effect on them and if any important actions needed to be taken for the last case study.

Meaning and generalizability

The results of this study provide new knowledge regarding the students' and teachers' views and expectations towards knowledge work practices in a course in health informatics and also show the degree to which Trialogical approach of learning can be applied in that setting by following certain steps and guidelines. The results provide an insight of what would be an efficient way to apply the Trialogical learning design principles, what to avoid and what to consider throughout the course implementation.

Even though these results cannot be easily generalized due to the limitations described, general conclusions can be made. This study was carried out in a certain kind of course in health informatics where students needed to provide real health informatics solutions to real health related problems. Several courses in health informatics demand from their students to provide such solutions to health related problems. Conclusions and specific suggestions of this study can be used to apply Trialogical learning in similar settings in health informatics education by following recommendations on what to do and what to avoid.

In general, not too much research has been carried out regarding the implementation of Trialogical learning in healthcare education. One study was found and where the Trialogical learning design principles were used as an inspiration to design relevant knowledge work practices needed for a specific medical simulation-training course. The study showed that the transformation of the course did have a positive impact and managed to improve the medical teams' practices in critical care contexts such as the emergency room. More specifically, they managed to design specific knowledge creation activities and practices that helped to develop practices that would have not possible to develop otherwise [50].

Therefore, by utilising Trialogical learning in a way that fits the needs of the specific context and develops related knowledge creation practices is an important

issue. The utilisation needs to be carried out in a thoughtful and innovative way. By modifying a course according to Trialogical learning could be the means of providing an important step towards developing the desired knowledge work practices. What is essential to do is to find the way to best implement the Trialogical approach of learning according to the specific needs of the setting and the needs of the participants.

4.3 Further Study

Due to time limits there are several aspects that this study did not cover to a sufficient extent. First, a similar study could include more representatives in order to confirm the results of this study or redesign the study in a smarter way by using other tools or train the participants more adequately on the tools. Secondly, a more complete implementation of all the design principles could be performed in order to explore in depth their application and effect in health informatics education.

How would for example the implementation of the rest of the design principles affect the participants' views towards Trialogical learning? What should be avoided and what should be followed throughout their implementation? Could the national background of the participants affect the implementation and acceptance of the Trialogical learning design principles? Students from Europe for example, might work best individually but students from Asia might prefer more group work. Last but not least, an analysis of whether the participants' competencies changed due to the implementation of the Trialogical approach would also be an interesting topic.

5 Conclusion

Formal education is challenged as today's students live in a society that is profoundly different from what it used to be. Globalization, international competition and technology have raised the need for new types of competencies that represent modern knowledge work practices. Regarding health informatics education, there is a need to prepare students to meet the needs of the market since there is a gap between what education delivers and what employers expects.

Triological learning is a novel pedagogical approach that was designed to target modern knowledge work practices through the implementation of a set of design principles during the course realization. This study firstly explored the views and expectations of students and a teacher in a health informatics course towards knowledge work practices in their education. Next, in order to organise work in the course to target modern knowledge work practices, Triological learning was applied and a transformation was achieved up to a good point.

All in all, this research showed that transformation and design of a course under such an approach is quite time consuming and demanding as lots of planning and research needs to be carried out before, during and after the implementation of the course. The application of the design principles alone is not enough and the technology to be used needs to accommodate specific needs and requirements.

The results of this study provide great input as far as health informatics education is regarded. More specifically, the methodology that was used to transform the case studies course to target modern knowledge work practices could provide a promising direction for further research on this field in order to improve how educational design is implemented in health informatics education and how it could be further improved.

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Appendices

APPENDIX A

KNORK - Template for planning and describing pedagogical scenarios

TITLE OF THE SCENARIO: Case Studies in Health Informatics

Author(s): [Researcher's name, Teacher's name]

Institution: Karolinska Institutet

Course name: Case Studies in Health Informatics

Course instructor(s): [Teacher's name]

Target populations: 1st year master students in Health Informatics

No. of students: 23

Content areas/Disciplines: Health Informatics

Duration of the course: March - May 2014

No. of instructional hours: The course has only two hours of instruction in the beginning of the course where the teacher shows to the students the different ways of tackling case studies and then the students are expected to use the learning material and work on their own in order to provide their solutions to the cases.

Ideas and reasons for developing the course:

This course is devoted entirely to case studies in health informatics. The course will provide an introduction to the case study pedagogy, and continue with studying four cases related to health informatics. The cases describing health informatics scenarios are presented in writing.

The first two case studies are analysed individually in case essays, and all students prepare to be able to account for the analysis orally. In the last two case studies students are divided in groups of 4-6 students where the problems and the solutions are discussed and presented collaboratively through digital means. The students though still have to write an individual essay for their analysis. All case studies are treated in seminars held approximately 4 weeks apart.

Plan for implementing the Trialological design principles:

<i>Design principle</i>	<i>Implementation in own teaching</i>
DP1: Organizing activities around shared objects	<p>Shared Objects:</p> <ul style="list-style-type: none"> - Padlet: Common wall for all groups and private walls for the groups to share and organize ideas around the case - Popplet: Private group popplets for mind mapping of the problem and solution for the case - Trello: Private group boards to organize time and activities around the case and the course - Prototype solution from each group for the case <p>Activities: Groups of 4-6 students (preferably mixed groups, medical and technical background) collaborate (face to face or online), submit and present their shared objects, and individually write an essay analysis</p> <p>Process:</p> <ol style="list-style-type: none"> 1. All students meet once with the teacher in a face-to-face seminar and who explains to them the goals and deliverables of the case study. The teacher shares the case study handout and the guidelines on how to solve it in groups and individually. 2. Then the students form groups and start working on the case studies for a period of four weeks before they meet again in a seminar to present their solutions. They are expected to read, analyse the case and write down their individual reports and also work on the tools (Popplet, Padlet, Trello) as a group in order to prepare their solutions. In the meantime the students can participate in the discussion forum for more clarifications or questions. 3. Two days before the seminar, students can upload their preliminary individual case report. 4. During the seminar students are active by presenting their solutions in their groups. 5. Two days after the seminar students can improve their preliminary individual case reports and upload their final reports.
DP2: Supporting integration of personal and collective agency and work	<p>Participants: The groups consist of students who take different positions according to their background (medical or technical).</p> <ul style="list-style-type: none"> - Students with technical background <ul style="list-style-type: none"> o Can define, describe and discuss problems o Can explain, discuss and decide the technical aspects of the solution - Students with medical background <ul style="list-style-type: none"> o Can define, describe and discuss problems o Can explain, discuss and consider aspects such as specific requirements related to specific medical

	conditions
	<p>Collective activities: Students take the responsibility for the group case study solution. They are expected to define roles in the group so that everyone contributes equally.</p> <p>Collective responsibility: All members in a group should contribute in the group solution. They should decide on their own how each one does this. There is freedom to choose on which parts of the solution each member will contribute. Through Padlet and Popplet all members of the group can easily see who did what and also to add on or improve what has already been written.</p> <p>Practical Problems: Students follow predefined templates for their individual report. For the group work, the tools (Padlet, Popplet and Trello) have already been set up for them in order to start using them the way they feel most comfortable with. Through Padlet and Popplet they can visualize their ideas and mind map their solutions. Through Trello they can organize their time plan. Finally, they can take part in the common forum where all students in the case studies course can discuss. If students need help they can always send messages to the teachers and get the supervision needed.</p> <p>Reflection: Students are expected to reflect on their individual report regarding their collaboration in the group</p> <p>Previous achievements: The course is conducted in the beginning of the second semester of the first year and students are expected to use the knowledge they have gained till then for the project.</p>
DP3: Emphasizing development and creativity through knowledge transformations and reflection	
DP4: Fostering long-term processes of knowledge advancement	<p>Iterations: Students in the groups work on a prototype that they present during the seminar and can modify later according to the feedback they get. Also, they can improve their first version of the individual report after the seminar is conducted.</p> <p>Planning use for the outcomes: Training for future professional career focusing on interpersonal development.</p> <p>Extending idea development: The course is based on real health informatics problems that are identified in other courses in the program or from the student's own earlier experiences.</p> <p>Collaboration with professionals: The case studies are examples from real health informatics problems where real professionals play the role of the client. Students are expected to provide solutions without contacting the clients. The clients can be present during the seminars where the groups present their solutions and provide feedback.</p>
DP5: Promoting cross-fertilization of knowledge practices and artefacts across communities	

DP6: Providing flexible tools for developing artefacts and practices

Shared problem: Students, teachers and real professionals have different backgrounds and collaborate in order to solve a shared problem.

Templates and tools: Students use real professional templates to plan, write and organize their solutions.

Reflections: Students can reflect during the seminar when presenting their solutions, through the discussions forum and also get face-to-face feedback from the clients and the teachers during the seminar.

Ping Pong is used as a Learning Management System (LMS) and which provides certain functions (e.g. PIMS, messages, common folders, learning material, group discussion, reminders, logbook) that facilitate the students.

Tools and organization: Ping Pong, Padlet, Popplet, Trello

Tools and learning community: Ping Pong, KI email, Padlet

Tools and shared artefacts: Common folder through Ping Pong, common wall through Padlet, common area for mind mapping through Popplet and common board for time management and organization through Trello

Tools and reflection: Discussion forum in Ping Pong

COURSE PLAN

Pedagogical context

The course has room for modification. There is room for further collaboration and interaction between the students, as well as of usage of digital tools and monitor their group process and individual progress. Students should have passed the courses from their first semester.

Curriculum link:

<http://pingpong.ki.se/public/courseId/10834/coursePath/5549/9658/10318/ecp/lan-g-en/publicPage.do?item=7605022>

Objectives

Intended Learning Outcomes

Knowledge and Understanding	- Synthesize theoretical knowledge within health informatics
Skills	<ul style="list-style-type: none">- Identify actors in interdisciplinary health informatics scenarios and explain and reflect on their professional roles and mutual professional relations,- Identify, analyse and categorize problems within healthcare or research that has connection to the management of information and knowledge and suggest potential health informatics solutions to these problems,- Reflect on potential health informatics method's suitability depending on the special characteristics of the problem and on contextual factors,- Evaluate, suggest, argue and recommend a solution in favour of others based on their effects and with regard to ethical and legal aspects.
Attitudes	- Develop a problem, patient and clinically oriented attitude in their professional role as health informaticians

ICT tool(s)

Ping Pong, KI email, Padlet, Popplet, Trello

Preparations before the each case study

Prepare the case studies, prepare Ping Pong (creating folders for the groups, workspaces, discussion forum, upload learning material), create in Padlet the walls for all the groups, create in Popplet the spaces for group mind mapping and create organization boards in Trello for the group project management.

Description / "manuscript" of the pedagogical design

Phase 1: Handout of case text

- Students create groups for the group work
- Students take part in the discussion forum for clarifications or questions
- Teachers are active in the forum by replying to questions

Phase 2: Read, analyse and write

- Students read individually the case study
- Use the digital tools to discuss and provide a solution to the problem in their groups

- Start creating a prototype for the group solution

Phase 3: Hand-in preliminary report (two days before the seminar)

- Students individually hand in their individual reports.
- Teachers read the preliminary reports and know where students stand and what might be needed to be discussed more during the forthcoming seminar

Phase 4: Seminar

- Students present their group solution
- Students discuss and are active during the seminar
- Teachers coordinate the seminar so that everyone takes part

Phase 5: Hand-in final report (two days after the seminar)

- Students can modify and improve their preliminary report if they want to
- Students upload their final report

Links and materials

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Experiences, development ideas and alternative solutions

An alternative solution would be to cooperate with other medical universities where there could be an online collaboration and interaction by providing feedback, tutoring, templates, health informatics scenarios, extra teaching material etc.

APPENDIX B

Digital Tools Description

Tool	Characteristics	Link
Padlet	Padlet is a free tool, which can be used collaboratively by many people in the same time. It is actually a digital wall where anyone can put a post on it and then organize these posts according to the categories they belong. Also someone can post on this wall images, links, documents etc. It is an interesting tool that can promote collaboration and innovation through an innovative way.	http://padlet.com
Popplet	Popplet is a free tool that can be used collaboratively by many people in the same time. It is a tool that helps mind map and organize your ideas through popplets, which can be edited according to the users' needs. Users can add in the popplets images, links or even draw in them.	http://popplet.com
Trello	Trello is a free collaborative project management tool that can help users manage their projects by organizing them into boards. In these boards the users can add other users and assign activities or resources and see what needs to be done and who is working on what and until when.	https://trello.com

APPENDIX C

Interview with the teacher in the beginning of the course

1. How is the course organized today?
2. What teaching methods do you use?
3. What kind of technologies do you use for the implementation of the course?
4. What kind of cases do students tackle?
5. What kind of knowledge should students obtain?
6. What kind of skills are students expected to obtain?
7. How is the examination conducted?
8. What kind of collaboration do students have?
9. How are the case studies projects delivered?

Appendix D

Teacher's pre – interview when the modified course would begin

Please look at the following design principles and answer the questions below concerning your new project plan

These are the six Trialogical design principles:

- 1) Organizing activities around shared “objects” (plans, reports, models)
- 2) Supporting integration of personal and collective agency and work
- 3) Emphasizing development and creativity through knowledge transformations and reflection
- 4) Fostering long-term processes of knowledge advancement
- 5) Promoting cross-fertilization of knowledge practices and artefacts across communities and institutions
- 6) Providing flexible tools for developing artefacts and practices

1. How and why is the Trialogical approach appropriate for your own course?
2. How is your plan different from the previous implementations of the course and why?
3. What bothers or puzzles you in the implementation of the new course plan?

Appendix E

Teacher's post-interview when the modified course was finished

Please look at the following design principles and answer the questions below concerning your new project plan

These are the six Trialogical design principles:

- 1) Organizing activities around shared “objects” (plans, reports, models)
- 2) Supporting integration of personal and collective agency and work
- 3) Emphasizing development and creativity through knowledge transformations and reflection
- 4) Fostering long-term processes of knowledge advancement
- 5) Promoting cross-fertilization of knowledge practices and artefacts across communities and institutions
- 6) Providing flexible tools for developing artefacts and practices

Design principles / theory

Look at the design principles together: Did the design principles get realized in the course plan as intended (how did they contribute)?

Collaboration

How successful was the planned collaboration (what worked well and what should be done differently)?

Technology

How would you evaluate the usage of technology (what succeeded well and what should have been done differently)?

Challenges in the background that motivate change

Did the course successfully address the challenges of previous implementations of the course?

Issues of concern

What would you do differently if the course were implemented again?

Appendix F

Students' web questionnaire in the beginning of the course

Pre-questionnaire Case Studies

You are a participant in the Case Studies in Health Informatics (VT14 5HI005) course. These pre-questions are one part of the research of the course and they have been agreed with the teacher of the course. The questions relate to the promotion of knowledge work practices in education and the research is conducted by Elnta Meragia (second year master student in Health Informatics in Karolinska Institutet) as part of her master thesis and part of the European Project called KNORK. More information about the project is available at the following website: <http://stepseurope.weebly.com/projects.html>

The researcher is going to use e.g. materials produced by the course participants, group interviews, and participants' reflection as data in the research. I kindly ask You for the permission to use the material related to You for research purpose. Research data will be collected, handled, analysed and stored confidentially. Only the researcher of the project will know the identity of respondents. The research results will be reported according to the good ethical research practices.

Contact information: elnta.meragia@stud.ki.se

Your participation or non-participation in the research does not have any influence on your study assignments or assessment of this course or your other university studies.

If you accept this request, please write your name below.

1. I give my consent to use the materials collected from the course for research purposes
2. How old are you?
3. What background do you have? (Pick one from the following)
 - Medical

- Technical
- Both
- Other (Please specify)

4. How long work experience do you have (in years)? (Pick one from the following)

- 1 – 3
- 4 – 6
- 7 – 9
- More than 10

5. How much do you use or rely on the following during your everyday activities? (Pick one from the following for each item)

Digital Means	1 Not at all	2 Very little	3 Some	4 A lot	5 I cannot live without
Computer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tablet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mobile	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mobile applications	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Social Media	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. From 1 to 10 how comfortable would you say that you are with technology?

7. Studying skills

Assess using the scale 1 – 5 (1=strongly disagree – 5=strongly agree) how well do the following statements describe your skills at the moment. Please, consider your responses in relation to your major subject studies in university.

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1.1 I know how to organize my studies purposefully	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1.2 I know how to analyze theoretically the topics to be studied	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1.3 I know how to discuss with others about the topics to be studied	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1.4 I know how to take advantage of common discussions for deepening my understanding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1.5 I know how to work in a goal-oriented way in a group	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1.6 I know how to develop productions (e.g. plans, reports, models) collaboratively with others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1.7 I know how to use technology in multiple ways during collaborative work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. What kind of thoughts and expectations do you have about the Case Studies course, its forms of studying and goals? What do you want to achieve by taking part in this course?

Appendix G

Students' Group Interviews in the end of the 3rd case study

A. Team Functioning Questions

1. How did your team function?
2. How did you meet and collaborate?
3. Are there aspects of the team's functioning that have been difficult or problematic?
4. Are there aspects of the team's functioning that have worked well?
5. What would you do differently in the team functioning now?
6. What kind of roles did you have in your team?
7. How did you divide the work?
8. How much did you comment or revise each other's work?

B. Content and problem solving processes

1. How did you find out new knowledge?
2. How would you evaluate your team's presentation and produced knowledge?
3. What would you do differently concerning the content?

C. Technology

1. What have been the most helpful/most disturbing features of the digital tools you used during the group work?
2. Can you think of any additional tools that would have been valuable for the team's work?

D. General

1. Is there otherwise something special in the teamwork that you could tell about?

Appendix H

Students' CKP Web Questionnaire, end of the Case Studies

This is the final Contextual Knowledge Practices Questionnaire. We are interested in your views on learning during the course as well as your course practices. This questionnaire is administered as part of the researcher's (Elnta Meragia, second year master student in Health Informatics) thesis and a European research project called KNORK (Promoting knowledge work practices in education <http://stepseurope.weebly.com/projects.html>)

Research data will be collected, handled, analysed and stored confidentially. Only the researcher of the project will know the identity of the respondents. The research results will be reported according to the good ethical research practices and only anonymous data will be presented.

Contact information: elnta.meragia@stud.ki.se

We would appreciate your input very much!

1. Background Information

1. Name and Surname:
2. University/College:
3. Course you participated in:
4. Age:
5. Gender:

2. Learning During the Course

This section includes questions about the knowledge and skills that you have learned during the course. **Evaluate how well each statement corresponds to what you have learned during the course using the following scale:** 0 = Not applicable to my studies, 1 = Strongly Disagree – 5 = Strongly Agree

During the course I have learned ...

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	0 Not applicable
2.1 To give feedback on the work of others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2.2 To evaluate the development of a shared product.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2.3 To work on products that are later used by others or myself.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Course Practices

This part of the questionnaire focuses on the course in which you have participated. When answering the questions, think about your own small group during the course, and if there was no small group, think about the study group in its entirety. If the groups changed during the course, think about the group with which you worked most. Think also about the products (e.g. reports, essays, summaries, etc.), that you prepared in your group in order to complete the course.

Evaluate how well each statement corresponds to the course practices using the following scale: 0 = Not applicable to my studies, 1 = Strongly Disagree – 5 = Strongly Agree

During the course practices:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	0 Not applicable
3.1 I was able to pursue both my own interest as well as advance the work on shared products.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3.2 In the course, various ways of examining the topic were applied.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3.3 During the course, we were able to utilize the expertise of people from various domains.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

More questions followed up in this questionnaire but are not included in this report for ethical research reasons

General Comments

4. What other skills and competencies have you learned during the course?

5. Comments to the teachers of the course

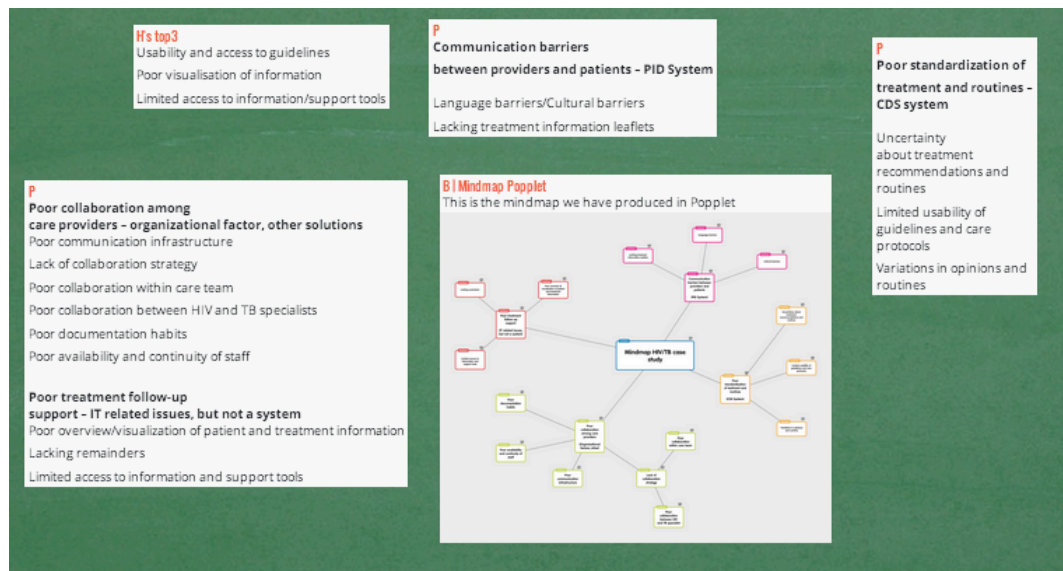
6. Comments to the developers of the questionnaire

We ask for your consent to use your responses in the researcher's (Elnta Meragia, second master student in Health Informatics) thesis carried out within the framework of a European Project called KNORK (Promoting knowledge work practices in education <http://stepseurope.weebly.com/projects.html>). By clicking Finish Survey you give permission to use the data. Only the researcher of the project will know the identity of the respondents. Only anonymous data will be presented and research data will be collected, handled, analysed and stored confidentially. The research results will be reported according to the good ethical research practices.

Contact information: elnta.meragia@stud.ki.se

Appendix I

Padlet Unstructured Wall Example



Appendix J

Padlet Structured Wall Example

